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The impact of monetary policy on a labor market with heterogeneous workers: The case of Chile

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ABSTRACT

We use a factor-augmented vector autoregressive (FAVAR) model to analyze the effect of a contractionary monetary policy shock on macroeconomic aggregates and labor market indicators for different demographic groups in Chile classified by industry, age, and income quintile. Inflation is negatively correlated with unemployment across groups. The model shows that most groups' job-separation rate and wage volatility increase after an interest rate rise. The response of the job-finding rate is mixed, decreasing in some groups and rising in others after an interest rate shock. The labor market in the primary sector is the least sensitive to monetary shocks.

1. Introduction

The economic effects of monetary policy have been broadly studied using different empirical and theoretical approaches. Most studies show that monetary shocks impact output and that inflation negatively responds to a contractionary monetary policy shock (Christiano et al., 1999). Furthermore, recent empirical studies for the United States show that the welfare costs of recessions are significantly higher if one accounts for job displacement risk (Krebs, 2003, 2007) and its heterogeneous impact on different agents (De Santis, 2007). Wage volatility in the United States is countercyclical (Storesletten et al., 2004, 2001), especially among workers experiencing unemployment (McKay and Papp, 2011). Households face substantially larger earnings shocks during recessions (Davis et al., 2011; Guvenen et al., 2014; Storesletten et al., 2004, 2001), and these earnings losses are highly persistent (Davis et al., 2011).

In this article, we study how different groups of workers in Chile react to the business cycle and changes in monetary policy. We analyze the effect of a monetary policy shock on the job-finding and separation rates, wage volatility[1], and labor productivity of different groups of workers. We classify workers into 45 distinct groups by (a) economic sector (primary, secondary, services, or tertiary), (b) age (16-35, 36-54, and 55 or older), and (c) income quintile (with lowest income being quintile 1 and highest income being quintile 5). We then estimate a factor-augmented vector autoregressive (FAVAR) model to analyze the transmission effect of a monetary policy shock on the labor market experiences of the different groups.

The FAVAR impulse-response functions show that the job-separation rate and wage volatility tend to increase after a contractionary monetary shock. However, economic sectors react differently. The secondary industry significantly reacts to increasing the job-

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[1] Note that our definition of wage volatility is "labor income volatility", not "salary volatility". While "salary" is often fixed in formal contracts, even formal full-time workers experience substantial wage volatility due to bonuses (Madeira, 2015) and overtime hours of work (Madeira, 2014).

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separation rate and the idiosyncratic wage volatility. The job-finding rate has a mixed response to an interest rate rise. However, for some demographic groups in the secondary and tertiary sectors, the job-finding rate falls significantly after a contractionary monetary shock. The reason for the mixed response of the job-finding rate could be related to the added-worker effect in which some members of the family search for new employment more intensively after the job loss of a spouse or relative during a contractionary shock (Blanchflower, 2021; Guner et al., 2020; Stephens, 2002). The added-worker effect is more relevant in developing economies such as Chile (Lee and Parasnis, 2014). Overall, the primary sector reaction to monetary policy regarding employment flows is lower, whether as job-separation or creation and wage volatility. This could be due to the higher presence of informality in the agriculture-silviculture sector (BCentral, 2018), with agriculture-silviculture employing more than 80% of informal workers (Perticara and Celhay, 2010), although other primary industries, such as mining, use little or no informal labor.

Madeira's (2015) rich data set measures the labor market experiences of different Chilean workers. Using the National Employment Survey, which covers a sample of 35,000 households quarterly, Madeira (2015) estimated the job-separation rate (the probability of an employed worker losing their job in the next three months ahead), the job-finding rate (the likelihood of an unemployed worker finding a job within three months), and their wage volatility (the standard deviation of the annual change in labor earnings). The results showed that Chile has a fluid labor market (Jones and Naudon, 2009), with unemployment inflow and outflow rates similar to the United States and substantially higher than other OECD countries (Elsby et al., 2012). Also, the average employed worker faced idiosyncratic income shocks with a standard deviation of 18% (Madeira, 2015), which is roughly similar to the volatility found in other countries (Krueger et al., 2010).

Relative to previous studies of the business cycle in Chile, such as Del Negro and Schorfheide (2008), we innovate by using measures of how monetary policy and the business cycle affect heterogeneous workers and different economic sectors. For instance, ours is the first work to measure real labor productivity growth for each of the three economic sectors in Chile. We show that productivity growth is strongly correlated for all industries. This is evidence that labor flows occur in different economic sectors and that in the long term, productivity in various sectors can be driven by common factors such as technology that create a significant correlation. There could be permanent productivity gaps among the economic sectors, but changes in productivity levels are strongly correlated. We also find that unemployment, separation, job-finding rates, and wage volatility are heterogeneous across worker types, yet a robust cyclical component affects all groups. Low-income workers experience both higher unemployment rates and wage volatility. However, low-income workers have a higher job-finding rate and therefore face shorter unemployment spells, perhaps because their job matches involve less specific human capital.

Income and age categories in our study can also be understood as a proxy for skill levels. Our work complements studies of the effects of monetary policy on labor income inequality, especially because low-skilled labor is more affected by the business cycle and experiences a higher degree of matching inefficiencies (Dolado et al., 2021). Other studies show that younger workers suffer more from the unemployment and wage shocks of the business cycle, with scar effects that can last over an entire life (BCentral, 2018), which makes it relevant to document their sensitivity to monetary policy. Furthermore, the poorer households are young, work at higher rates in sectors subject to the business cycle, such as manufacturing and construction, and experience more informality or poorer labor attachments[2].

In addition to being related to studies of workers' heterogeneous income shocks during the business cycle (Storesletten et al., 2001, 2004), our study also relates to the empirical research about the cyclical fluctuations of the labor market (Madeira, 2014; Mumtaz and Zanetti, 2012; Pappa, 2009; Trigari, 2009). Estimating a structural vector autoregressive (SVAR) model, Ravn and Simonelli (2007) concluded that hours worked, employment, vacancies, and the vacancies-unemployment ratio decrease in response to an increase in the federal funds rate. Moreover, labor productivity declines briefly and increases after a few quarters. Monetary policy also affects real wages, which seems inconsistent with a high degree of nominal rigidity in the labor market. Using a standard VAR reduced form, Olivei and Tenreyro (2007) found that an expansionary money shock increases wages and hours. This work is also related to previous studies of monetary policy in emerging markets (Arroyo et al., 2022; Martínez and Oda, 2021; Tobal and Menna, 2020), and it extends these studies by including a labor market with the heterogeneity of workers across sectors and ages. Some previous studies also had the financial market effects of monetary policy (Madeira and Madeira, 2019).

Moreover, the response of wages is mildly procyclical, while the hours worked react more significantly when the shock occurs in the first and second quarter of the calendar year. Peneva (2013) showed that hourly earnings respond positively to an expansionary monetary shock, similar to the services and goods sectors. Braun et al. (2009) estimate an SVAR model for the United States, including demand and supply shocks. They find that an expansionary monetary shock increases vacancies and job-finding and job-creation rates, whereas it decreases the separation and job-destruction rates. Finally, they concluded that responses induced by supply shocks are more persistent than those caused by demand shocks.

This work is organized as follows. Section 2 summarizes the evolution of labor productivity, employment flows, and wage volatility for Chile's primary, secondary, and tertiary sectors over the last 23 years. Section 3 summarizes the literature and theoretical framework. Section 4 describes the structure of the FAVAR model estimated from the macro variables and the labor market statistics for each of the 45 demographic groups in our data. Section 5 summarizes the main results, while Section 6 discusses the policy implications. Finally, Section 7 concludes.

[2] Apart from labor experiences, some of the other sources of heterogeneity across households have shown to be small in Chile. For instance, an analysis of the households' consumption baskets for this period shows that the inflation experiences across families of different income levels were very similar, except for a brief period in 2008 during a recession induced by the Great Financial Crisis (Cobb, 2012).

Table 1
Distribution of the growth rates (%) of the consumer price index (CPI) and real productivity (PRO) by percentile. Quarterly data 1996:1-2012:4.

Variable (quarterly growth)	Mean	P10	P25	P50	P75	P90
Consumer price index (CPI)	0.88	0.12	0.52	0.80	1.21	1.81
Real productivity in all sectors (PRO)	0.61	-1.06	-0.04	0.50	1.65	2.04
Real productivity primary sector (PRO1)	0.66	-2.71	-0.63	0.76	2.33	4.45
Real productivity secondary sector (PRO2)	0.47	-2.22	-0.59	0.50	2.25	3.72
Real Productivity tertiary sector (PRO3)	0.62	-0.62	0.09	0.64	1.33	2.05

Note: Pi, $i = 10, 25, 50, 75, 90$, this is the sample percentile of the variables.

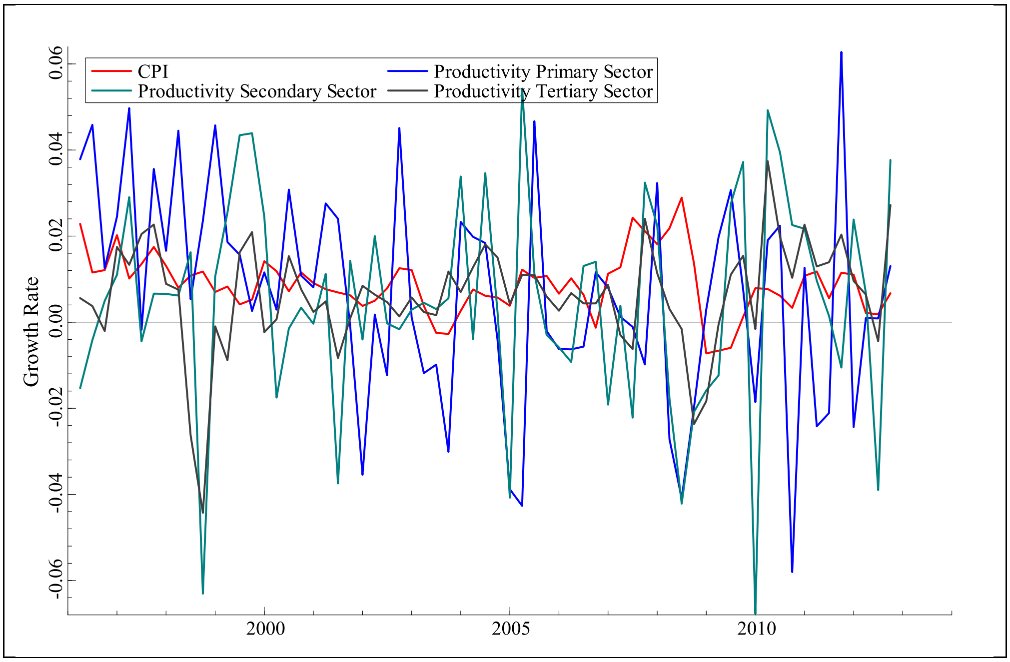

Fig. 1. Consumer Price Index (CPI) and real productivity growth by industrial sector.

2. The evolution of labor markets in Chile

We now describe the evolution of Chile's macroeconomic series and labor markets. Table 1 shows that the quarterly CPI growth rate fluctuates between values as low as 0.12% (the 10th percentile for all periods between 1996 and‘ 2012) to as high as 1.81% (the 90th percentile for all periods). It is worth noting that because these are quarterly values, 1.81% corresponds to an annualized inflation of 7.24%. The median and average quarterly CPI for 1996-2012 are 0.52% and 0.88%, respectively, well within the 2% to 4% range for the annual inflation target followed by the Chilean Central Bank. Chile's economic sectors have exhibited robust real productivity growth at average rates between 0.47% and 0.66%.[3] The primary sector was the industry with both the highest mean productivity growth and the most volatile one, with rates ranging from as low as -2.71% (the percentile 10th observed for the period 1996-2012) and as high as 4.45% (the percentile 90th during the same period). In particular, the tertiary sector has a much lower volatility in real productivity growth than the other sectors, which can be interpreted as the primary and secondary sectors being increasingly subject to international competition and open-economy shocks.

Fig. 1 plots the actual evolution of quarterly growth rates of the CPI and the real productivity for each economic sector from 1996 to 2012. CPI and the real productivity of the three sectors of economic activity are relatively uncorrelated over this period. However, most positive and negative spikes in real productivity growth coincide for the primary, secondary, and tertiary sectors, which shows that all labor markets are strongly correlated. This indicates that labor markets in Chile are integrated across different industries. Labor flows make productivity gains correlated across the various economic sectors.

Table 2 reports the correlation coefficients between each pair of aggregate variables for 1996-2012. We report the correlation for the variables in their pure form and Hodrick-Prescott (H.P.) cyclical components, which can give different results for real productivity

[3] The primary sector in Chile, which considers agriculture and forestry, fishery, and mining activities, accounted for 16.2% of the real GDP in 2012. The secondary sector, corresponding to the manufacturing industry, represented 11.5% of the real GDP. Finally, the tertiary sector accounted for 72.3% of the real GDP.

Table 2
Correlation coefficients of the CPI and real productivity growth with the overall unemployment flows and wage volatility—quarterly data 1996:1-2012:4.

Correlation of the standard variables (%)							
	CPI	PRO	U	EU.	UE	STDI	I1
Consumer price index (CPI)	100						
Real productivity (PRO)	-2.5	100					
Unemployment rate (U)	-27.3	-12.4	100				
Separation rate (EU.)	-19.5	-2.8	55.2	100			
Job-finding rate (UE.)	28.7	8.4	-71.2	13.5	100		
Wage volatility (STDI)	-20.8	10.4	38.5	13.1	-34.0	100	
Long-term interest rate (I1)	-69.2	-7.7	2.2	27.5	16.3	4.9	100
Correlation of the Hodrick-Prescott cyclical component (%)							
	CPI	PRO	U	EU.	UE	STDI	I1
Consumer price index (CPI)	100						
Real productivity (PRO)	-3.7	100					
Unemployment rate (U)	-12.3	3.6	100				
Separation rate (EU.)	-14.7	-2.4	71.2	100			
Job-finding rate (UE.)	11.3	-14.6	-21.6	45.1	100		
Wage volatility (STDI)	-15.1	15.9	24.6	5.8	-26.2	100	
Long-term interest rate (I1)	-91.8	-16.0	11.21	15.5	-4.4	7.3	100

(PRO). In general, CPI fluctuations have a low correlation with real productivity growth. CPI growth is negatively correlated with unemployment and separation rates but positively correlated with the job-finding rate. This is evidence of the traditional short-term Phillips curve, with inflation and unemployment negatively associated (Christiano et al., 1999). The real productivity growth for the labor force has a low correlation with labor market variables such as unemployment, separation, and job-finding rates, which might be interpreted as evidence of short-term rigidity in the Chilean labor market. Wage volatility[4] is positively correlated with the unemployment rate and negatively associated with the job-finding rate, showing that in Chile, idiosyncratic wage risk also increases during recessions, similar to the United States (McKay and Papp, 2011; Storesletten et al., 2001, 2004). Both the separation and job-finding rates have a high correlation with unemployment, which shows that job creation and destruction play a role in unemployment fluctuations (Elsby et al., 2012; Fujita and Ramey, 2009).

In general, the long-term interest rate has a low correlation with the job-finding rate and wage volatility. However, the separation rate, CPI, and the long-term interest rate are highly correlated in their pure form and HP cyclical component form. The job-finding rate is positively correlated with the long-term interest rate in the pure form. Yet, this relationship is negative when the HP cyclical component is analyzed, indicating that, over the business cycle, contractionary monetary policy shocks and job-finding rate decreases might coincide. Furthermore, since the long-term interest rate positively correlates with the unemployment rate, unemployment spells might coexist with contractionary monetary policy shock. This result is consistent with the finding in Salazar (2019), indicating that unemployment is a function of the long-term interest rate and that monetary policy is not entirely neutral in the long run.

In Table 3, we report the correlation matrix for the HP cyclical components of each economic sector. Real productivity growth for the primary, secondary, and tertiary sectors is correlated with the overall economy's productivity growth of 54%, 72%, and 89%, respectively. This is evidence that labor flows occur across different economic sectors, and long-term productivity gains are tightly related.

CPI growth negatively correlates with unemployment and separation rates only in the primary and secondary sectors. However, the job-finding rate positively correlates with CPI growth in the secondary and tertiary sectors. This shows that the primary industry

[4] Our work uses the wage volatility of all workers in each group (given by age, income quintile, industry). Another research question would deal with the wage volatility of workers in the same job versus those moving to new jobs. However, this question cannot be analyzed over such a long period. The reason is that wage volatility is measured from rotating samples in the Chilean Labor Force Survey, that is, workers that remain in the sample for four quarters (Madeira, 2015). However, measuring the wage volatility of workers that move between jobs is difficult to implement from the survey data for several reasons: (i) workers who lose their job and then move to a new job are a small fraction of the sample (around 2.5% of the labor force, according to Madeira, 2015), which makes their wages difficult to measure in a survey, especially once a researcher adds heterogeneity across different groups and over time; (ii) since rotating samples are only kept for four quarters, then this measurement would miss the workers who would take several quarters to find a job. Measuring wage volatility for new jobs versus old jobs is currently possible due to the availability of confidential administrative data from the tax authorities (BCentral, 2018). However, this data has two shortcomings: (i) it does not capture the period before 2005 (which would substantially reduce the time by cutting off both the expansion before the Asian crisis, the Asian crisis recession and its subsequent recovery); (ii) the administrative tax data does not capture informal jobs unlike the survey data (note that the survey data measures the employment status and earnings of all workers in the economy, although it does not have a category variable that allows separating workers according to the formality of their contract) and informal employment (around 28% of the labor force) represents a significant margin of adjustment during the business cycle (BCentral, 2018), with such workers likely experiencing much higher wage volatility.

Table 3
Correlation coefficients of the CPI and real productivity growth with the economic sector's unemployment flows and wage volatility. Quarterly data 1996:1-2012:4.

Sector		Correlation of Hodrick-Prescott cyclical component (%)							
		CPI	PRO	PRO1	U	EU.	UE	SDTI	I1
Primary	Consumer price index (CPI)	100							
	Real productivity (PRO)	-3.7	100						
	Productivity primary sector (PRO1)	-11.7	54.3	100					
	Unemployment rate (U)	-12.8	2.6	13.1	100				
	Separation rate (EU.)	-10.6	5.3	5.3	81.8	100			
	Job-finding rate (UE.)	-3.7	-2.3	-6.1	15.5	64.1	100		
	Wage volatility (SDTI)	-7.4	18.6	0.6	3.9	0.7	-5.3	100	
	Long-term interest rate (I1)	-91.8	-16.0	5.4	6.2	2.8	3.2	-4.4	100
Secondary		CPI	PRO	PRO2	U	EU.	UE	SDTI	I1
	Consumer price index (CPI)	100							
	Real productivity (PRO)	-3.7	100						
	Productivity secondary sector (PRO2)	-14.0	72.1	100					
	Unemployment rate (U)	-26.4	-0.4	7.3	100				
	Separation rate (EU.)	-27.7	-8.3	2.4	77.3	100			
	Job-finding rate (UE.)	14.9	-17.5	-12.9	-36.4	18.1	100		
	Wage volatility (SDTI)	-17.4	17.0	16.6	34.3	20.0	-32.7	100	
	Long-term interest rate (I1)	-91.8	-16.0	4.4	25.5	35.0	-0.6	8.5	100
Tertiary		CPI	PRO	PRO3	U	EU.	UE	SDTI	I1
	Consumer price index (CPI)	100							
	Real productivity (PRO)	-3.7	100						
	Productivity tertiary sector (PRO3)	7.0	88.9	100					
	Unemployment rate (U)	0.1	6.3	3.5	100				
	Separation rate (EU.)	-2.2	-1.8	-1.3	68.6	100			
	Job-finding rate (UE.)	13.9	-16.4	-9.1	-11.1	53.8	100		
	Wage volatility (SDTI)	-14.6	14.3	13.5	23.2	0.3	-29.0	100	
	Long-term interest rate (I1)	-91.8	-16.0	-28.9	-5.8	-2.4	-8.9	7.5	100

reacts to inflation shocks mostly in job destruction, while the tertiary sector reacts to inflation shocks regarding job creation. The secondary sector, however, responds to inflation shocks regarding job creation and destruction.

The correlation between the long-term interest rate and unemployment and separation rates is higher and positive in the secondary sector. By decomposing the economic activity into sectors, it is possible to state that the negative correlation between the long-term interest rate and the real productivity (see Table 2) might be explained by the negative association between the long-term interest rate and the real productivity in the tertiary sector. Additionally, in Table 2, it was stated that the job-finding rate negatively correlates with the long-term interest rate. This result seems to be explained by the negative association between both variables in the tertiary sector.

In all economic sectors, the unemployment and job-separation rates are highly correlated, with coefficients between 69% and 82% for each sector. Still, the correlation between unemployment and the job-finding rate is much lower. This evidence argues that job destruction is responsible for most of Chile's cyclical movement in unemployment. Wage volatility is high and positively correlated with unemployment fluctuations only in the secondary and tertiary sectors. Therefore, only the secondary and tertiary sectors show a simultaneous cycle of high unemployment and high idiosyncratic wage volatility.

Finally, Figs. 2–4 show the evolution of the labor market variables (wage volatility, unemployment, separation rate, and job-finding rate) for the primary, secondary, and tertiary sectors. We show the different evolution for the workers in each national income quintile (with quintile 1 representing the lowest income and 5 the highest). Several facts stand out. First, a significant seasonality exists in the unemployment, separation, and job-finding rates, which is most substantial for the primary sector. Second, the shocks affecting all workers have a significant common component because unemployment, job-separation, and job-finding rates tend to move together for all income quintiles. Also, the unemployment rate is lowest for all economic sectors for workers in the income quintiles four and five, except for the secondary sector during the 1990s.

Similarly, the highest-income workers (quintile 5) show the lowest job-separation rates in all sectors and periods. Finally, in all the economic sectors, wage volatility is highest for the bottom income quintile, whereas workers of quintiles 3 and 4 have the lowest idiosyncratic wage volatility. The differences in wage volatility are quite substantial, with workers in quintile 1 having wage volatility of around 40% to 50%. In comparison, the workers in quintiles 3 and 4 have values of just 6% to 12%. Curiously, Figs. 2–4 show that wage volatility increases during recessions (such as the 1999 and 2009 economic downturns) and expansions (such as the year 2006), perhaps due to increased job reallocation when the economic cycle changes.

Since labor flows, unemployment, and wages are measured from household surveys, most countries find it hard to keep comparable labor series for long periods due to methodological breaks (Blanchflower, 2021; Howell et al., 2007). The data lower bound is due to a methodological break in 1996 for measuring labor productivity by sector (Madeira, 2015). Due to Chile becoming an OECD member in 2010, a methodological change in the measurement of the labor force determines the upper bound. This change caused

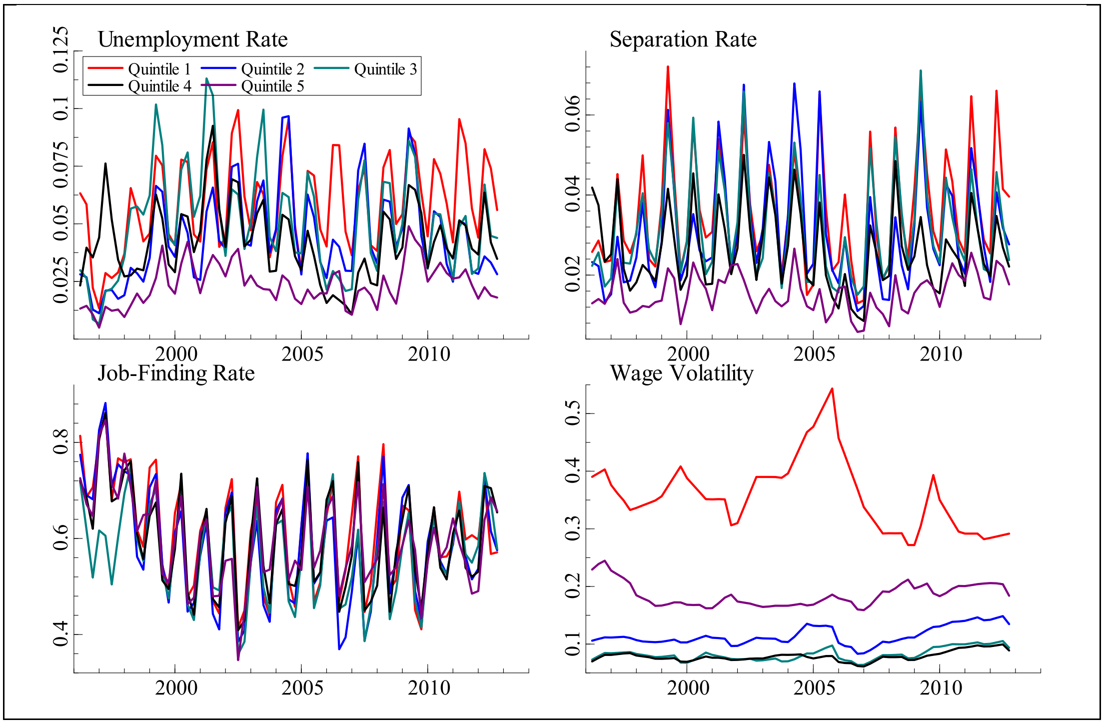

Fig. 2. Wage Volatility, Unemployment, Separation, and Job-Finding Rates in the Primary Sector (according to the National Income Quintile of the Workers).

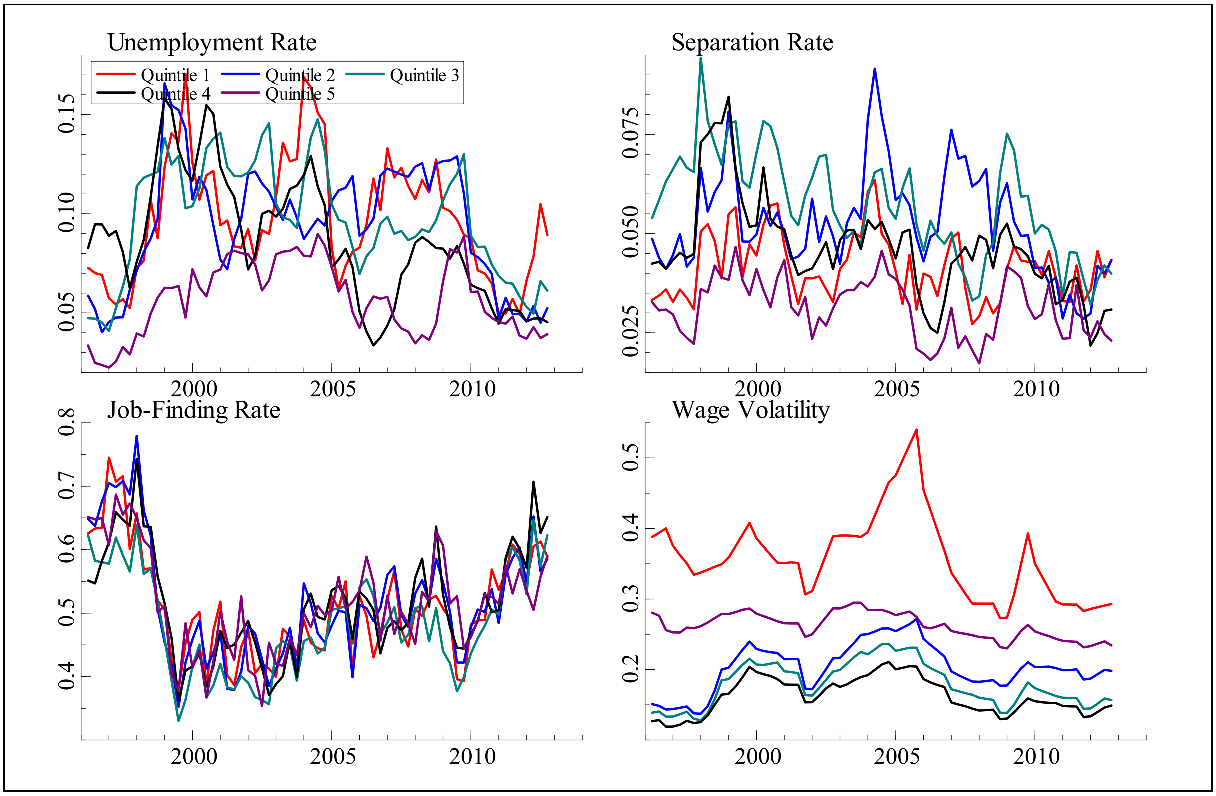

Fig. 3. Wage Volatility, Unemployment, Separation, and Job-Finding Rates in the Secondary Sector (according to the National Income Quintile of the Workers).

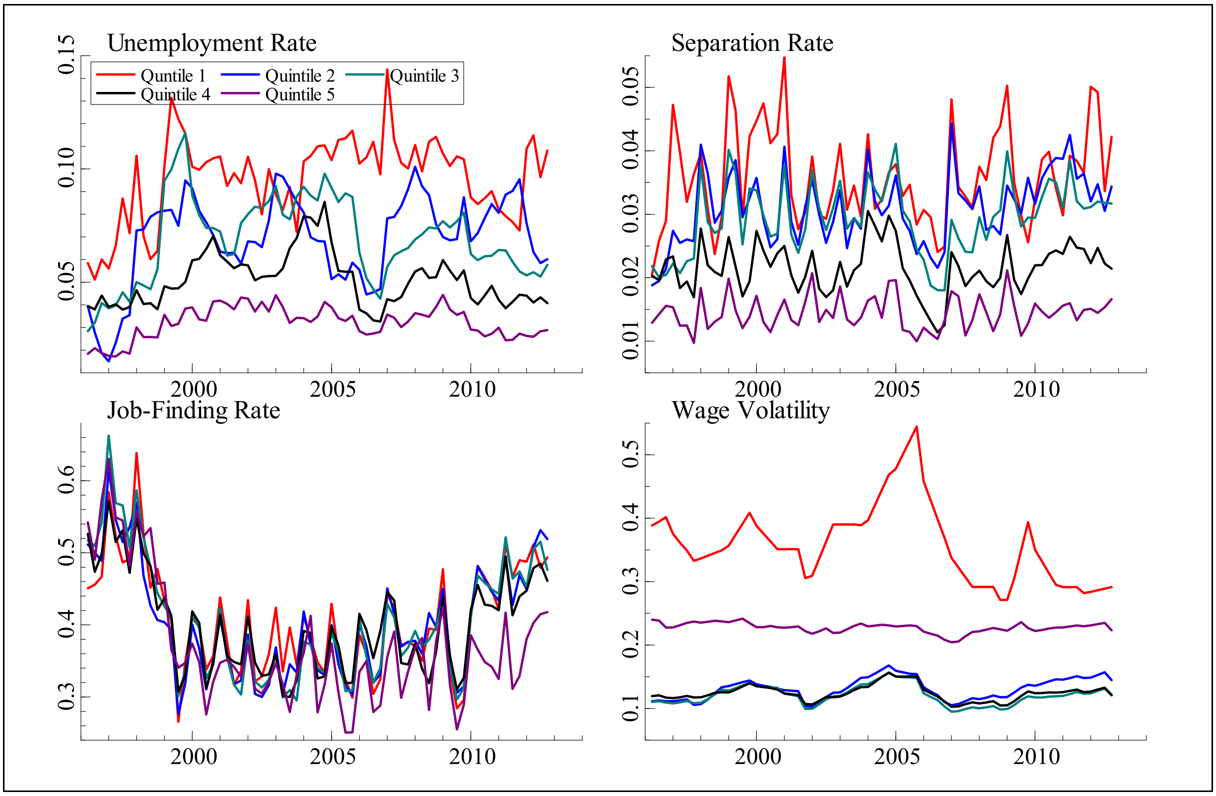

Fig. 4. Wage Volatility, Unemployment, Separation, and Job-Finding Rates in the Tertiary Sector (according to the National Income Quintile of the Workers).

the information up to 2012 to be not comparable with the subsequent information captured by the new survey. Furthermore, a second break occurred in 2018 due to the Institute of National Statistics changing the population numbers to account for the large immigration numbers observed in Chile after 2017 (Albagli et al., 2017; BCentral, 2018).

On the methodological side, this article uses labor flows and wage volatility shocks across worker groups available from Madeira (2015). This methodology uses the rotating sample of the labor force survey (that is, the same workers observed in contiguous quarters) to measure the job-separation rate as $\lambda_{i,t}^{EU} = \Pr(u_{i,t} = 1 \,|u_{i,t-1} = 0, x_i, t)$ and the job-finding rate as $\lambda_{i,t}^{UE} = \Pr(u_{i,t} = 0 \,|u_{i,t-1} = 1, x_i, t)$, or labor flows of workers in transit between employment to unemployment and unemployment to employment, respectively. Other methods are possible such as obtaining implicit job-separation and job-finding rates from the dynamics of total employment, total unemployment, and short-term unemployment (Shimer, 2005). However, these methods can suffer from compositional bias since workers enter and exit the labor force (Shimer, 2012). Some studies also measure labor flows for economies with high labor informality, such as Peru (Reynaga and Ramírez-Rondán, 2021). However, in Chile, it is impossible to obtain adequate classifications of employment informality in the Labor Force Survey before 2009, which is essential for our business cycle empirical analysis, which started in 1996.

3. Theoretical framework

Our study is closer to the FAVAR literature initiated by Bernanke et al. (2005), which uses factors estimated from many objective activity measures to identify the transmission mechanism of monetary policy more precisely. However, our study is also related to the literature on theoretical and empirical macroeconomics of heterogeneous agents. The VAR literature, to which the FAVAR model belongs, differs from macroeconomic theory by shifting the research focus to analysing empirical patterns to verify data-coherent theories rather than calibrating a specific theoretical model (Bernanke et al., 2005). Models with heterogeneous agents and aggregate risk are essential in modern macroeconomics. Perhaps the first work in this literature started with Mankiw (1986), who shows that macroeconomic phenomena such as the equity premium puzzle require that shocks affect agents differently and that the recessions' costs are concentrated on a few agents. Den Haan (1996) then analyses the relationship between interest rates and the number of agent types, showing that heterogeneous agent models can be intractable due to the high number of possible state variables. Krusell and Smith (1998) present a solution to a stochastic growth model with heterogeneous agents. They show that the evolution of capital can be guessed by a simple function of mean wealth instead of depending on the wealth of each agent. Their model allows for both idiosyncratic and aggregate risk. Castaneda et al. (1998) represent the joint evolution of heterogeneous income and wealth in the USA.

Heathcote et al. (2009a) show that heterogeneity is relevant for aggregate outcomes due to the uninsurable income risk inducing savings and labor supply changes, affecting both quantities and prices. Income inequality is increasingly essential to understand the business cycle due to skill-biased technical change, fluctuations in the labor share, borrowing constraints, and political economy shocks (Quadrini and Ríos-Rull, 2015).

Heterogeneity is also essential to assess the impact of aggregate shocks and who bears the costs of business cycle fluctuations. For instance, Glover et al. (2020) document that during the Great Financial Crisis of 2007, the young were more hurt by the employment and income losses, but the older generations suffered more from the steep drop in asset prices.

Although the last decades saw considerable advances in the macroeconomic theory, there has been a strong critique of the New Keynesian model framework, particularly its empirical performance and failure to explain some puzzles (Galí, 2018). Nevertheless, the New Keynesian framework and its more recent HANK developments remain the dominant macroeconomic theory to understand and formulate policy due to its two primary features: nominal rigidities and monetary non-neutralities. Over the past ten years, the New Keynesian models addressed many phenomena and improved its financial transmission mechanisms, household heterogeneity, and nonlinear propagation channels (Galí, 2018).

The 2010s saw the development of models incorporating household heterogeneity into the standard New Keynesian framework, commonly referred to as HANK (Heterogeneous Agent New Keynesian) models (Galí, 2018; Kaplan et al., 2018). These models sought household heterogeneity, financial frictions, and nonlinearities as propagation mechanisms that could explain the Great Financial Crisis of 2007. HANK models are not necessarily superior to the more traditional New Keynesian DSGE (Dynamic stochastic general equilibrium) framework. For instance, Kaplan et al. (2018) point out that current HANK models are very stylized and do not include many of the standard features of the DSGE, such as investment adjustment costs, variable capital utilization, habit formation, prices, and wages that are partially sticky as opposed to perfectly rigid.

For HANK models, the indirect effects of changes in wages, borrowing capacity, uninsurable income risk, illiquid returns, and government budget constraint can have a stronger impact than the direct effects caused by intertemporal substitution and income effects (Kaplan et al., 2018). Consumption is, therefore, more sensitive to income and less sensitive to interest rates in HANK models, making it more relevant to study inequality (Kaplan and Violante, 2018). Ahn et al. (2017) show that inequality matters more for aggregate outcomes due to illiquid wealth, capital-skill complementarity, and factor-specific productivity shocks.

More specifically related to labor markets, the heterogeneous impact of monetary policy is explained mainly through the analysis of two channels: financing frictions related to the firm size and sectorial heterogeneity associated with price stickiness and elasticity of substitution between durable and nondurable goods sectors (Barsky et al., 2003, 2007; Erceg and Levin, 2006; Howes, 2021; Singh et al., 2022). Singh et al. (2022) also analysed employment by firm size, finding that small firms are less sensitive to contractionary shocks but more susceptible to expansionary shocks.

The first channel—the financing friction channel—is based on the idea that working capital restrictions exist, so firms must borrow to finance their working capital. Therefore, an increase in the interest rate would decrease the labor demand through financing constraints.

Specifically, the model proposed by Singh et al. (2022) uses heterogeneous firms facing financial frictions and working capital constraints, and the monetary policy affects employment through three mechanisms. The first relates to the financial accelerator mechanism that causes constrained firms to react more to a monetary policy shock under working capital constraints (Bernanke et al., 2005).

The second mechanism is based on unconstrained firms being able to borrow more and hiring workers at a lower cost than constrained firms. Then, due to the upward-sloping marginal cost curve, unconstrained firms react more regarding employment to a monetary shock.

The third mechanism relates to the wage effect, which states that firms react differently to a wage decrease following a monetary contraction. Even if the wage decrease is homogeneous among firms, their response will not be since constrained firms pay a spread on the amount they borrow, unlike unconstrained firms. Therefore, unconstrained firms are more responsive to monetary shocks. Then, as far as the combined effect of the wage and marginal cost effects is stronger than the accelerator effect, unconstrained firms, mainly large firms, will be more responsive to a contractionary monetary policy shock.

The second channel—price stickiness and elasticity of substitution—states that durable goods investments (mostly related to the manufacturing and construction sector) are more sensitive to monetary policy shocks than investments in nondurable goods (primarily associated with the service sector). The reason is that durable goods exhibit a higher substitution elasticity and lower price stickiness than nondurable goods.

The approach of our paper is more empirically based than some of the heterogeneous agent literature. Still, it is a highly relevant empirical study since, as Sims (1980) argued, theoretical macroeconomic models often are based on restrictive identification assumptions and the calibration of unknown parameters. The critical insight of the FAVAR approach is that identification of the effects of monetary policy shocks requires only a plausible identification of the shocks and does not need the calibration of a full macroeconomic model (Bernanke et al., 2005).

Our work concentrates on the effects of monetary policy on heterogeneous labor markets. However, it does not elucidate which channel explains the effect of monetary policy on each group of workers. Monetary policy can impact real activity through several channels (Boivin et al., 2010), such as New Keynesian channels (such as price and wage rigidities, as expressed by the Phillips Curve), Neoclassical channels (including the cost of capital, wealth effects on consumption, the intertemporal substitution of consumption, exchange-rate and exports activity), and Credit-based channels (such as banks' lending capacity, the firms' balance-sheets, and corporate risk premia). Monetary policy may affect some groups of workers differently because (i) some industries are more susceptible to price and wage rigidities (Barattieri et al., 2014; Bils et al., 2012; Dolado et al., 2021; Gorodnichenko and Weber, 2016); (ii) some industries have a higher degree of external finance dependence and are therefore more susceptible to credit frictions (Bernanke et al., 1999; Rajan and Zingales, 1998); (iii) high-skilled workers have a higher capital-skill complementarity (Dolado et al., 2021). Our work does not show which channels explain the heterogeneous effect of monetary policy on different worker groups. It is even possible that other channels can distinctly affect different workers. Therefore, perhaps the business cycle behavior of some worker groups is due to price-wage rigidities, and a credit channel of monetary policy could drive certain industries. However, answering these questions for Chile would require much information, such as measuring price-wage rigidities for each industry[5]. Examples of empirical work, however, show that the credit-based channel of monetary policy is a significant factor in Chile (Alfaro et al., 2005; Arroyo et al., 2022; Barajas et al., 2008), although it is uncertain how this channel affects different industries. These questions are left for future research.

Our current methodology and data do not study the transmission mechanism of the monetary policy shock due to the lack of relevant data on industries' price-age rigidity and credit for the industry firms employing each group of workers. Such a question could be addressed using an SVAR framework, but this is left for future research. This article aims to obtain a robust measurement of the heterogeneous monetary policy effect across different groups of workers using a reduced-form FAVAR methodology.

4. The FAVAR model

We estimate a FAVAR model for the Chilean economy using quarterly macroeconomic data and the panel labor time series from Madeira (2015) for the quarterly period 1996:2-2012:4. The FAVAR contains three lags and three unknown common factors,[6] and we assume that the only observable factor is the interest rate, as in Bernanke et al. (2005). The following system presents the model:

$$\begin{aligned} \begin{bmatrix} \mathbf{F} \\ \mathbf{Y} \end{bmatrix}_t &= \Phi(L) \begin{bmatrix} \mathbf{F} \\ \mathbf{Y} \end{bmatrix}_{t-1} + \boldsymbol{\mu}_t \\ \begin{bmatrix} \mathbf{X} \\ \mathbf{Y} \end{bmatrix}_t &= \begin{bmatrix} \boldsymbol{\Lambda}^f & \boldsymbol{\Lambda}^y \\ \mathbf{0} & \mathbf{I} \end{bmatrix} \begin{bmatrix} \mathbf{F} \\ \mathbf{Y} \end{bmatrix}_t + \begin{bmatrix} \mathbf{e} \\ \mathbf{0} \end{bmatrix} \end{aligned} \tag{1}$$

$\mathbf{F}$ is a 3-dimensional vector containing the unobservable factors, $\mathbf{Y}$ includes the long-term interest rate[7], $\Phi(L)$ is a lag operator of order 3, $\boldsymbol{\Lambda}^f$ is a matrix of parameters of dimension 142×3 indicating how each variable relates to the unobservable factors, while $\boldsymbol{\Lambda}^y$ is a matrix of parameters with the dimension 142×1 that shows how the observable variables $\mathbf{X}$ relate to the interest rate. Fig. 15, in Appendix B, shows that the long-term interest rate closely follows the monetary policy rate over the entire period. The results in Table 11 show that both variables are cointegrated with an estimated pass-through close to one. These results indicate that using the long-term interest rate is a valid proxy for monetary policy. Finally, we assume $\boldsymbol{\mu}_t \sim N_4(0, \Omega)$ and $\boldsymbol{e}_t \sim N_{142}(0, \boldsymbol{\Gamma})$, with $\boldsymbol{\mu}_t$ and $\mathbf{e}_t$ being independent.

$\mathbf{X}$ is a 142-dimensional vector containing 135 labor series and seven macroeconomic variables. The labor series includes the job-separation rate (EU, the employment to unemployment probability), the job-finding rate (UE, the unemployment to employment probability), and the standard deviation of the total labor earnings (SDTI) of the workers for each of the 45 different demographic groups.[8] The total labor earnings include permanent and temporary labor income measured in the fourth quarter of each year (Madeira, 2015). We classify each group according to age (16-35 years old, 36-54 years old, and 55 or older), economic sector (primary, secondary, and tertiary), and income quintile (with quintile 1 being the lowest income group and five the highest income)[9]. The seven macroeconomic variables include money stock (M3), the consumer price index (CPI), the real exchange rate (RER), copper price (CP), and productivity in the primary, secondary, and tertiary sectors (PRO1, PRO2, and PRO3, respectively).[10] In addition, we classify all variables $\mathbf{X}$ as slow-moving or fast-moving variables, where the former do not contemporaneously react to the interest rate. We extract unobservable factors from the group of slow-moving variables $\mathbf{X}$.

[5] There is some research on price-wage rigidities across industries in the US (Bils et al., 2012; Barattieri et al., 2014; Gorodnichenko and Weber, 2016), but not for Chile.

[6] The results of the FAVAR estimation are robust to the use of an additional unknown factor.

[7] We use the long-term interest rate instead of the monetary policy interest rate. See Appendix B for further information.

[8] We classify the 45 mutually exclusive groups according to the workers' ages, income quintiles, and economic sector. Let $i = 1, \ldots, 45$ be expressed by vector $z = \{economic\ sector(m),\ age(n), income\ quintile(q)\}$, with each variable assuming respectively a set of discrete values: $m = \{1 : \text{Primary}, 2 : \text{Secondary}, 3 : \text{Tertiary}\}$, $n = \{1 : 16\text{–}35,\ 2 : 36\text{–}54,\ 3 : \geq 55\}$, and $q = \{1, 2, 3, 4, 5\}$. Then $i = 1, \ldots, 45$ corresponds to the following mutually exclusive values of matrix z : $1(z = [1, 1, 1]),\ 2(z = [1, 1, 2]), \ldots, 45(z = [3, 3, 5])$. Table 12 in Appendix D shows the identification number of each group and its age-sector-income quintile description.

[9] The variables we choose to denote the worker groups are age, economic sector, and income quintiles. The income quintiles are a standard way of measuring inequality in the economics literature and are widely used both in academic literature (Castaneda et al., 1998) and in official country reports (such as the OECD or World Bank reports). Age is an essential variable in measuring workers' position in the life cycle and returns to experience (Attanasio and Weber (2010)) and is highly relevant to the study of social security questions in macroeconomics (Kaplan and Violante, 2018). The economic sector (primary, secondary, tertiary) is relevant for a small open economy like Chile, which shows a high degree of export specialization in commodities such as copper and agricultural products. Differences by sector are especially important for macro labor market movements because aggregate labor shares can hide shocks affecting specific sectors (Elsby et al., 2013).

[10] The series, data sources, and transformations are described in Table 10.

Table 4
Response summary of the macroeconomic and labor variables to one standard deviation positive shock to the interest rate.

Variable	Increases	Decreases	No response
Macroeconomic variables			
Real money stock (M3)		(4)	
Consumer price index (CPI)		(4)	
Real exchange rate (RER)		(3)	
Real copper price (C.P.)			(0)
Real productivity primary sector (PRO1)	(1)		
Real productivity secondary sector (PRO2)			(0)
Real productivity tertiary sector (PRO2)		(3)	
Number of responses in labor variables			
Job-separation rate (EU)	20	2	23
Job-finding rate (UE)	10	10	25
Wage volatility	22	11	12

Note 1: The number in $(\cdot)$ is the length of the response, expressed in quarters.
Note 2: There are 45 mutually exclusive groups per labor variable (EU, UE, and STDI). Each group is classified by economic sector, age, and income quintile.

We estimate the system of equations using joint likelihood-based Gibbs sampling. That is, we calculate the characterization of the joint posterior density, $P(\theta, \mathbf{F}^T|\mathbf{X}^T, \mathbf{Y}^T)$, by sampling from the conditional densities $P(\mathbf{F}^T|\theta, \mathbf{X}^T, \mathbf{Y}^T)$ and $P(\theta|\mathbf{F}^T, \mathbf{X}^T, \mathbf{Y}^T)$, where a superscript T indicates that the respective vector[11] includes all the sample information from period 1 until period T and $\theta = [\mathbf{\Lambda}^f, \mathbf{\Lambda}^y, \mathbf{\Gamma}, vec(\mathbf{\Phi}), \mathbf{\Omega}]$. We estimate the model by imposing the restrictions $\mathbf{\Lambda}^f \mathbf{D}^{-1} = \mathbf{\Lambda}^f$ and $\mathbf{\Lambda}^y + \mathbf{\Lambda}^f \mathbf{D}^{-1}\mathbf{B} = \mathbf{\Lambda}^y$ obtaining a unique identification of the factors and their loadings with $\mathbf{D}$ a non-singular and $\mathbf{B}$ conformable matrix.

All variables in the vector $\mathbf{X}$ must be simultaneously analyzed to account for the heterogeneity observed in the Chilean labor market. Given the high dimension $\mathbf{X}$, using a vector of autoregression (VAR) approach to study the transmission mechanism of a monetary shock would provide less meaningful results because degrees of freedom are lost. VAR systems are usually estimated when the number of variables is small (6-8) and the sample size is large. Bernanke et al. (2005) suggested that a natural solution to the degrees-of-freedom problem is using common factors to summarize a significant amount of economic information. In addition, given the heterogeneity, the factors might capture some diffuse economic concepts related to the labor variables.[12]

5. Empirical results

5.1. Effects of monetary policy shocks on the interest rate, money stocks, CPI, exchange rate, and productivity

We now present an impulse-response analysis of a contractionary monetary policy shock. After estimating the FAVAR model, we analyze how a positive standard deviation shock to the interest rate affects labor productivity (PRO) of each economic sector (primary, secondary, tertiary), job-finding (UE), and job-separation (EU) rates, wage volatility (SDTI), and macroeconomic variables (money aggregate, CPI, and real exchange rate). Table 4 reports the summary of the responses, classified according to whether the variable experiences an increase, decrease, or no response after a contractionary monetary shock. Additionally, Fig. 5 shows the impulse-response function for the macroeconomic variables in vector $\mathbf{X}$.

As expected, Fig. 5 shows that a contractionary monetary shock is associated with an interest rate increase and a decline in the money stock (M3) and real exchange rate. The real exchange fall shows that Chile's price index is partially rigid. Therefore, the real exchange rate appreciates due to the nominal exchange rate appreciation, which is common in the empirical macroeconomics literature. The contractionary monetary shock is also associated with a negative impact on the CPI and productivity of the tertiary sector. The copper price and the productivity of the primary and secondary sectors do not show a significant reaction after a contractionary money shock.

The upper part of Table 4 reports the response of the seven macroeconomic variables in vector $\mathbf{X}$. The value in brackets is the estimated duration time in quarters of the response to the contractionary monetary shock. In general, all macroeconomic variables show the expected sign response. For example, the consumer price index (CPI), money stock (M3), and real exchange rate (RER) show a negative response, lasting either three or four quarters to a contractionary monetary shock on average.[13] The copper price does

[11] For example, $\mathbf{Z}^T = [\mathbf{Z}_1, \mathbf{Z}_2, \dots, \mathbf{Z}_T]$.

[12] The average R^2 of the system describing X in (1) is 65.6% and 53.2% for the job-finding rate (EU) and wage volatility (SDTI), respectively. This suggests that two of the three estimated factors measure some economic concept related to these labor variables.

[13] The economic response lasting three or four quarters is consistent with most VAR studies (Christiano et al., 1999). Furthermore, the fact that we do not find a price puzzle is worth emphasizing. Customarily, empirical data analysis finds a positive correlation between inflation and the interest rate because policy makers increase interest rates to counteract periods of increasing inflation. Various studies use sign restrictions in the SVAR to identify shocks according to expected priors, which restricts the information to ignore the price puzzle from the outset. We do not use this

not exhibit a significant response to an increase in the interest rate, which we expected because the copper price is internationally determined. Productivity in the primary sector (PRO1) reacts positively to a rise in the interest rate. Still, this response lasts only one quarter, whereas the productivity in the tertiary sector shows a negative reaction that lasts three quarters. Finally, productivity in the secondary sector does not offer a significant response.

5.2. The reaction of the job-separation rate (EU)

Table 4 shows that in 20 of the 45 groups, the job-separation rate reacts positively to a contractionary monetary shock. Only two groups exhibit a negative response (although it is a minimal response in these two groups, as seen in Fig. 6). Fig. 6 shows that in the primary sector, there is a significant increase in the job-separation rate for the first four income quintiles, the first three quintiles, and quintile 3 of the age groups with 16-35, 36-54, and above 55 years, respectively. Two groups in Fig. 6 show a negative response to the job-separation rate (specifically, the quintile 4 of the age groups 36-54 and above 55 years), but it is a small and brief response. Fig. 7 shows that in the secondary sector, there is a significant increase in the job-separation rate for the quintiles 3 to 5, all the quintiles except the second, and all the quintiles except the fourth, for the age groups with 16-35, 36-54, and above 55 years, respectively. For the tertiary sector, Fig. 8 shows a significant increase in the job-separation rate for quintile 3, quintiles 3 to 5, and all the quintiles except the fourth, for the age groups with 16-35, 36-54, and above 55 years. It seems that the reactions of the poorest (quintiles 1 and 2) are the least statistically significant among the worker groups, which makes sense since, for these groups, there is the more intensive use of informal work that is harder to measure (Madeira, 2022) and also a more substantial added-worker effect in the labor participation composition (Lee and Parasnis, 2014).

Informal labor represents around 28% of Chile's labor force, and this share has been increasing in recent years due to a large influx of immigration (BCentral, 2018). The Chilean informal labor rate of 28% is one of the lowest in Latin America (where informal labor represents more than 50% of the workers in some countries). Still, it is much higher than developed countries 10% to 15% rate (BCentral, 2018). A recent analysis of the decade between 2010 and 2017 shows that informal labor expands more during periods of weaker economic growth, with workers facing lower wages even if unemployment remains stable (Barrero et al., 2018). However, it is impossible to create consistent time series of informality in Chile, especially before 2009, due to the lack of adequate questions in that aspect for the older waves of the labor force survey[14].

Given that labor intensity differs between economic sectors, the response of labor variables to monetary shocks may depend on the analyzed sector. For example, the service sector is more labor-intensive than the other sectors, suggesting that this sector might be more affected. The responses of each labor market variable (job-separation rate, job-finding rate, and wage volatility) by economic sector are summarized in Table 5 to investigate this statement.

Table 5 shows that the secondary sector is the most affected in the economy when we look at the response of the job-separation rate (EU). In 10 out of 45 groups in the secondary sector, the separation rate increases after a contractionary monetary shock, compared to six and four groups in the primary and service sector, respectively.

The average length of the increase of the job-separation rate in the primary sector (3.8 quarters) is more significant than in the secondary (3 quarters) and tertiary (2.5 quarters) sectors. Table 13 in Appendix E shows that the response in the primary sector is statistically more significant than in the secondary and tertiary sectors.

5.3. Reaction of the job-finding rate (UE)

In 10 of the 45 groups in Table 4, the job-finding rate responds negatively to the rise in the interest rate. In contrast, the opposite reaction is observed for 10 of the other groups (although this positive reaction is small and short-lived). The reason for the mixed response to the job-finding rate can be related to the added-worker effect in which some family members search for new employment

approach for three reasons. First, our sample is relatively short, and the identification of shocks using sign restrictions requires long time series for identification. Second, a VAR or SVAR works relatively well when the number of variables is not so big, but our study uses more than 100 labor market time series. Finally, when restrictions are imposed from the outset, it is difficult to discern which results are due to the assumptions made and which are due to the empirical facts (Christiano et al., 1999; Uhlig, 2005).

[14] Our measures of labor flows use the total labor force in each of the 45 groups (by age, income quintile, industrial sector), which consider the joint sum of formal and informal workers. The reason informal and formal workers are not measured as different panel series because we cannot obtain a consistent classification for formality for the entire period since 1996. This is because measuring unemployment and labor force participation are the major goals of labor force surveys in Chile and most countries; therefore, while these surveys include some questions that could be used to classify informality, there is no standard methodology and set of variables that could be applied to obtain time series of informal workers over this entire period. For instance, between 1996 and 2008, there is one question about domestic workers that classifies whether the worker is a "relative or an unpaid worker," therefore these workers would certainly classify as informal workers, and such workers represented 1.7% of the labor force in the fourth quarter of 2008. Then there is a question of classifying self-employed or wage workers in the private or public sectors. However, the crucial problem is that before 2009 no variable could separate self-employed or wage workers according to their contract type to establish whether they are informal workers. For instance, before 2009, it is impossible to separate a self-employed that works for a company and provides invoices or receipts of his work in relation to a self-employed that sells products on the street without any invoices. Before 2009, it is also impossible to separate workers with a formal contract with social security discounts in relation to workers that get paid a wage without any formal disclosure. Note that in some older studies the informality statistics come from the Socioeconomic Characterization Survey (CASEN), which is implemented every 2 years, but not from the labor force survey (Perticara and Celhay, 2010).

Table 5
Response of the labor variables by economic sector to one standard deviation positive shock to the interest rate.

Sector	Variable	Number of each type of response		
		Increase	Decrease	No response
Primary	Job-separation rate (EU)	6 (3.8)	1 (1.0)	8
	Job-finding rate (UE)	3 (2.0)	1 (6.0)	11
	Wage volatility (SDTI)	3 (3.0)	8 (1.8)	4
Secondary	Job-separation rate (EU)	10 (3.0)	-	5
	Job-finding rate (UE)	1 (2.0)	5 (4.2)	9
	Wage volatility (SDTI)	10 (3.0)	-	5
Tertiary	Job-separation rate (EU)	4 (2.5)	1 (2.0)	10
	Job-finding rate (UE)	6 (1.3)	4 (3.8)	5
	Wage volatility (SDTI)	9 (1.8)	3 (1.7)	3

Note: Each sector has 45 mutually exclusive groups (15 per labor variable) classified by age and income quintile. The number in $(\cdot)$ is the average length of the response, expressed in quarters

more intensively after the job loss of a relative during a contractionary shock (Blanchflower, 2021; Guner et al., 2020; Stephens, 2002). The added worker effect is most substantial in developing economies such as Chile (Lee and Parasnis, 2014).[15]

For the primary sector, Fig. 9 shows that a contractionary monetary shock has a negative effect on the job-finding rate for, respectively, all the quintiles except the fifth, quintiles one and five, and no quintiles for the age groups with 16-35, 36-54, and above 55 years. Quintile 3 of the age group 36-54 shows a positive reaction. For the secondary sector, Fig. 10 shows a negative effect for all the quintiles of the age groups 16-35 and 36-54 years, while for the oldest age group above 55 years, only quintiles 3 and 5 have a negative reaction. For the tertiary sector, there is a positive effect in the job-finding rate for the quintiles one to four of the youngest group of workers (those aged 16-35), which could be due to the added-worker effect of young adults entering employment when their parents are facing difficulties (Lee and Parasnis, 2014). For the age groups 36-54 and above 55 years in the tertiary sector, there are some quintiles with a positive effect and others with an adverse effect, but such results are minimal in size and tend to last only one quarter.

Table 4 shows that the job-finding rate reacts negatively to an interest rate increase for 10 of the 45 different demographic groups, and Table 5 finds that the probability that a worker will be hired after a contractionary monetary shock is lower both in the secondary and tertiary sectors (where five and four demographic groups are affected, respectively). Due to the increasing job-separation and the job-finding rate having a mixed response, unemployment typically increases following an interest rate increase. This result is exciting because the positive effects on the job-finding rate are small and brief. The overall impact of the contractionary interest rate results in a decrease in the job-finding rate. Fig. 16, in Appendix C, shows that after weighing the 45 worker groups to obtain the entire population, a statistically significant increase in the job-separation rate is observed. In contrast, the job-finding rate shows a non-statistically significant decrease (although it is almost significant around three quarters after the contractionary shock). This seems to imply that recessions induce labor flows into unemployment and create employment reallocation, and some sectors see an increased number of workers looking for vacancies (Davis et al., 1998; Elsby et al., 2012; Shimer, 2012), making the overall job-finding effect harder to determine.

5.4. *The reaction of wage volatility (SDTI)*

Finally, Table 4 shows that the standard deviation of earnings increased in 22 out of the 45 groups. Most of these groups belong to the secondary sector of the economy, as Table 5 shows. This result matches empirical evidence in the United States, which shows that idiosyncratic income risk increases during recessions (Davis et al., 2011; Guvenen et al., 2014; McKay and Papp, 2011; Storesletten et al., 2004, 2001).

For the primary sector, Fig. 12 shows that a contractionary monetary shock positively affects wage volatility for the lowest income quintile across all age groups. In contrast, it has a negative effect on quintile 2 across all the wage groups. Quintiles 3, 4, and 5 have a small negative effect on wage volatility for the age groups of 36-54 and above 55 years. A similar pattern is observed for the tertiary sector, as shown in Fig. 14. Therefore, there is a small negative effect of the contractionary monetary shock on the wage volatility of the middle-aged groups (36-54 and above 55), except for the lowest income quintile, which has the opposite reaction across all age groups. This result shows that the poorest groups suffer the worst income volatility during contractionary shocks. This makes sense since this group uses more informal employment and less attachment to the employer. Furthermore, it also makes sense that wage volatility may decrease for quintiles 2 through 5 because it includes positive shocks such as bonus income, which may disappear during contractionary periods.

[15] The impulse response for the aggregated job-finding and aggregated job-separation rates are shown and discussed in Appendix C.

Table 6
Participation (%) of the different demographic groups in the economy's total employment and employment by sector (average 1996:2-2012:4).

Group (age, quintile)	Sector			Total [5,934,921.9]
	Primary [864,089.5]	Secondary [1,319,939.5]	Tertiary [3,750,892.9]	
(1,1)	8.2	3.7	5.6	5.6
(1,2)	10.9	10.0	8.3	9.0
(1,3)	7.9	10.8	8.5	8.9
(1,4)	3.9	8.4	7.6	7.3
(1,5)	2.7	5.0	6.2	5.4
Subtotal	33.6	37.9	36.2	36.2
(2,1)	5.8	3.9	5.5	5.2
(2,2)	10.4	7.3	7.2	7.7
(2,3)	12.7	11.1	8.8	9.9
(2,4)	8.8	14.2	11.7	11.8
(2,5)	8.1	12.4	15.4	13.6
Subtotal	45.8	48.9	48.6	48.2
(3,1)	2.2	1.3	1.6	1.6
(3,2)	4.3	1.8	1.8	2.2
(3,3)	5.2	2.5	2.3	2.8
(3,4)	4.8	4.0	3.7	3.9
(3,5)	4.1	3.8	5.7	5.0
Subtotal	20.6	13.4	15.1	15.5
Total	100	100	100	100

Note 1: [] is the average number of employed people.
Note 2: (n, q) is (age, quintile) group.$n = \{1 : (16{-}35 \text{ years}), 2 : (36{-}54 \text{ years}), 3 : (\geq 55 \text{ years})\}$, and q is the worker's income quintile $q = \{1, 2, 3, 4, 5\}$.

For the secondary sector, Fig. 13 shows that a contractionary monetary shock positively affects the wage volatility for all the income quintiles of the age groups 16-35 and 36-54 years. There is also a positive effect on the wage volatility of the lowest income quintile of those above 55. This result makes sense since the manufacturing sector is the most exposed to foreign competition and experiences the highest shocks (Madeira, 2015; Madeira, 2022).

Furthermore, the length of the increase in wage volatility in the secondary sector (3 quarters) is higher than in the tertiary sector (1.8 quarters). When a 10% of significance is used, the length of the wage volatility increase in the primary sector (3 quarters) is statistically more significant than in the tertiary sector (1.8 quarters) (see Tables 5 and 13).

5.5. Heterogeneity of the labor flows and wage volatility across worker groups

The following analysis classifies the response of the labor flow variables and wage volatility (EU, UE, and SDTI) by demographic group (15 mutually exclusive groups) and economic sector (3 sectors). Each demographic group is represented by the pair (n, q), where n is an age classification $n = \{1 : (16{-}35 \text{ years}), 2 : (36 - 54 \text{ years}), 3 : (\geq 55 \text{ years})\}$, and q is the worker's income quintile $q = \{1, 2, 3, 4, 5\}$. For example, $(3, 5)$ is the group of workers aged 55 or older whose income belongs to quintile 5.

Table 6 shows the employment in each demographic group, presenting the information relative to employment in the whole economy and each economic sector. With a rate of 63.2%, the tertiary sector concentrates most of the employment in the economy, followed by the secondary sector (22.2%) and the primary sector (14.6%). The mid-aged workers (36-54) have the most employed (45.8%, 48.9%, and 48.6% in the primary, secondary, and tertiary sectors, respectively). Moreover, older workers (55 or older) with income in the first quintile have the lowest rate (2.2%, 1.3%, and 1.6% in the primary, secondary, and tertiary sectors, respectively).

Tables 7–9 report the qualitative responses for each economic sector about whether a variable increases, decreases, or shows no reaction after a contractionary monetary shock. These tables expand Table 5 by precisely showing the workers' age group and income quintile affected by monetary shocks within each economic sector. In addition, these tables provide a basic summary of the qualitative responses of the individual impulse-response graphs shown in Appendix A.

After a contractionary monetary shock, the FAVAR analysis shows that the secondary sector's job-separation rate increases relatively more. However, the contractionary monetary shock causes the job-finding rate to drop in the secondary and tertiary sectors, with people between the ages of 16 and 35 most affected. These results suggest that when contractionary monetary policy is at work, other policies (e.g., fiscal policy) could stimulate employment in the secondary sector and, mainly, youth employment in the tertiary and secondary sectors. Given the youth group consists typically of unskilled and inexperienced people and that an increase in the interest rate is likely to decrease the probability of finding a job for this group, an economic policy that increases the human capital of the youth (e.g., job training, higher education) and stimulates the hiring of people between ages 16 to 35 could counteract the adverse effects of a contractionary monetary shock

Table 7
Response of the labor variables in the primary sector by age and income quintile to one standard deviation positive shock to the interest rate.

Job-separation rate (EU) response	
Increase	(1,2), (2,1), (2,2), (2,3), (3,3), (3,5)
Decrease	(3,4)
No response	(1,1), (1,3), (1,4), (1,5), (2,4), (2,5), (3,1), (3,2)
Job-finding rate (UE) response	
Increase	(1,4), (2,3), (2,4)
Decrease	(1,1)
No response	(1,2), (1,3), (1,5), (2,1), (2,2), (2,5), (3,1), (3,2), (3,3), (3,4), (3,5)
Wage volatility (SDTI) response	
Increase	(1,1), (2,1), (3,1)
Decrease	(1,2), (2,2), (2,4), (2,5), (3,2), (3,3), (3,4), (3,5)
No response	(1,3), (1,4), (1,5), (2,3)

Note: (n, q) is a (age, quintile) group.$n = \{1 : (16{-}35 \text{ years}), 2 : (36{-}54 \text{ years}), 3 : (\geq 55 \text{ years})\}$, and q is the worker's income quintile, $q = \{1, 2, 3, 4, 5\}$.

Table 8
Response of the labor variables in the secondary sector by age and income quintile to one standard deviation positive shock to the interest rate.

Job-separation rate (EU) response	
Increase	(1,3), (1,4), (1,5), (2,1), (2,3), (2,4), (2,5), (3,1), (3,3), (3,5)
Decrease	-
No response	(1,1), (1,2), (2,2), (3,2), (3,4)
Job-finding rate (UE) response	
Increase	(3,2)
Decrease	(1,1), (1,2), (1,4), (2,2), (2,3)
No response	(1,3), (1,5), (2,1), (2,4), (2,5), (3,1), (3,3), (3,4), (3,5)
Wage volatility (SDTI) response	
Increase	(1,1), (1,2), (1,3), (1,4), (1,5), (2,1), (2,2), (2,3), (2,4), (3,1)
Decrease	-
No response	(2,5), (3,2), (3,3), (3,4), (3,5)

Note: (n, q) is a (age, quintile) group.$n = \{1 : (16{-}35 \text{ years}), 2 : (36{-}54 \text{ years}), 3 : (\geq 55 \text{ years})\}$, and q is the worker's income quintile, $q = \{1, 2, 3, 4, 5\}$.

5.5.1. Heterogeneous reactions of demographic groups in the primary sector

Within the primary sector, Table 7 suggests that after a contractionary monetary shock, the separation rate increases for the oldest workers (55 or older) in the income quintiles 3 and 5 and for the mid-aged workers (36-54) in income quintiles 1 through 3. Therefore, the separation rate change is clear-cut for the oldest workers with income equal to or above the middle class and the mid-aged workers with income like or below the middle class.

A contractionary monetary shock will likely negatively affect the employment of 49.1% of primary sector workers (see Table 6). Furthermore, after a contractionary monetary shock, the primary sector workers aged 16-35 in the lowest income quintile are less likely to find a job. In the primary sector, wage volatility also increases for the lowest-income quintile workers; this applies to all age groups. However, in the primary sector, wage volatility declines for older workers (55 or older) and mid-aged workers (36-54) across all income ranges.

5.5.2. Heterogeneous reactions of demographic groups in the secondary sector

Within the secondary sector, Table 8 shows that almost all workers experience an increase in the job-separation rate after a contractionary monetary shock. Moreover, mid-aged workers (36-54) in the mid-income range (quintiles 2 and 3) and the youngest workers (16-35) experience a decrease in the job-finding rate. Therefore, the secondary sector suffers a double impact of a contractionary monetary shock that increases job destruction (73.4% of people working in the secondary sector are likely to move into unemployment) and decreases job creation (40.5% of people working in the secondary sector are likely to experience a decrease in the probability of finding a job). Also, almost all workers in the secondary sector share an increase in wage volatility after a contractionary shock.

Table 9
Response of the labor variables in the tertiary sector by age and income quintile to one standard deviation positive shock to the interest rate.

Job-separation rate (EU) response	
Increase	(3,1), (3,2), (3,3), (3,5)
Decrease	(1,4)
No response	(1,1), (1,2), (1,3), (1,5), (2,1), (2,2), (2,3), (2,4), (2,5), (3,4)
Job-finding rate (UE) response	
Increase	(2,4), (3,1), (3,2), (3,3), (3,4), (3,5)
Decrease	(1,1), (1,2), (1,3), (1,4)
No response	(1,5), (2,1), (2,2), (2,3), (2,5)
Wage volatility (SDTI) response	
Increase	(1,1), (1,2), (1,3), (1,4), (2,1), (3,1), (3,2), (3,3), (3,4)
Decrease	(2,2), (2,3), (2,5)
No response	(1,5), (2,4), (3,5)

Note: (n, q) is a (age, quintile) group.$n = \{1 : (16\text{–}35 \text{ years}), 2 : (36\text{–}54 \text{ years}), 3 : (\geq 55 \text{ years})\}$, and q is the worker's income quintile $q = \{1, 2, 3, 4, 5\}$.

Table 10
Data sources, description, and transformation of the variables.

Variable	Description	Source	Transformation	Slow code
M1	Real money stock M1	Central Bank of Chile	log difference	0
CPI	Consumer Price Index	Central Bank of Chile	difference in growth rate	1
I1	1-year interest rate	Central Bank of Chile	-	0
PRO1	Real productivity primary sector	Our calculation	log difference	1
PRO2	Real productivity secondary sector	Our calculation	log difference	1
PRO3	Real productivity tertiary sector	Our calculation	log difference	1
C.P.	Real copper price	Central Bank of Chile	log difference	1
RER	Real exchange rate	Central Bank of Chile	log difference	0
EU_i	Job-separation rate	Madeira (2015)	-	1
UE_i	Job-finding rate	Madeira (2015)	-	1
$SDTI_i$	Mean standard deviation of the idiosyncratic annual change in total labor income	Madeira (2015)	difference	1

Note 1: All variables are seasonally adjusted using the Census X13 program.
Note 2: Slow code 1 stands for a slow-moving variable and 0 for a fast-moving variable. A slow-moving variable does not contemporaneously react to the interest rate.
Note 3: The 1-year interest rate is the nominal average weighted interest rate of the financial system for operations of 90 days to 1 year, deflated by the consumer price index.
Note 4: Real productivity is obtained by the ratio of the total aggregate value-added of each economic sector (published by the Central Bank of Chile) divided by the number of workers in each sector as given by the quarterly National Employment Survey calculated by Madeira (2015).

5.5.3. *Heterogeneous reactions of demographic groups in the tertiary sector*

Table 9 shows that in the tertiary sector, only the oldest workers (55 or older) experience an increase in their separation rate after a contractionary monetary shock (this represents 11.4% of the people working in the tertiary sector), whereas the youngest workers (16-35) are the only ones that experience a decrease in their job-finding rate; this group represents 30% of the people working in the tertiary sector. These groups also see an increase in wage volatility after a contractionary shock. Therefore, the results for the secondary and tertiary sectors show that idiosyncratic wage risk is countercyclical in Chile, just as in the United States (McKay and Papp, 2011; Storesletten et al., 2001, 2004).

6. Discussion of the results and their relevance for policy

Heterogeneous workers are relevant for the conduction of policy through three channels. The first channel is a dynamic feedback effect where aggregate shocks, including monetary policy, affect the distinct worker types. Knowing their heterogeneous responses helps better predict the aggregate outcomes' dynamic evolution (Ahn et al., 2017; Heathcote et al., 2009a).

A second channel is that the knowledge of workers' heterogeneous income risk changes the evaluation of the welfare costs of business cycle fluctuations.

A third channel is directly in terms of the policy goals. Fiscal policymakers care about the population welfare and can make transfers to protect the workers most affected by the economic downturns, as shown by the several government programs implemented during the Covid pandemic (Madeira, 2022). Besides governments, central bankers may also care about minimizing inequality even under an inflation-targeting regime (Acharya et al., 2021) or a "dual mandate" with concerns about inflation and output deviations (Wolf and McKay, 2022). This does not imply that inequality is part of a central banker's mandate. It only requires–subject to the restriction of maintaining the stability of inflation, output, and the financial environment–that the central bank also searches for the goal of minimizing negative downsides for most groups of workers. Under the heterogeneous and countercyclical income risk found in this article for Chile, fiscal policymakers and central bankers should mitigate inequality by reducing households' unequal exposures to aggregate shocks (Acharya et al., 2021; Acharya and Dogra, 2020). Cantore and Freund (2021) show that income redistribution effects during downturns are even more critical when financial frictions and adjustment costs limit the workers' asset market participation.

Knowledge of economic shocks' impact on heterogeneous workers is also relevant for welfare analysis and crucial questions for economies with aging agents such as social security (Heathcote et al., 2009b). Our research shows differences in workers of different ages and income quintiles, which helps understand the reaction of economies experiencing skill-biased technological shocks (Quadrini and Ríos-Rull, 2015).

The results of the different effects of the monetary policy and business cycle shocks on the heterogeneous workers are also related to the recent literature on the movements of the labor share. Substantial literature documented a decline in the labor share across many countries (Arroyo et al., 2022; Bergholt et al., 2022; Grossman and Oberfield, 2021). Elsby et al. (2013) show that movements in labor shares within industries were frequent even before the 1980s. Aggregate movements often hide substantial differences across industries (Davis et al., 2006; Elsby et al., 2013; Haltiwanger, 2015). Our work, with its focus on different sectors, is relevant for understanding labor markets, especially since recent empirical result shows that the New Keynesian models cannot explain the behavior of the labor share and real wages (Cantore and Freund, 2021).

7. Conclusions

We analyze how monetary policy affects the Chilean labor market regarding its economic sectors and demographic groups. We find that there is indeed heterogeneity in how different economic sectors react to monetary shocks. While fluctuations in real labor productivity growth are strongly correlated across various sectors, apparent differences are evident in the behavior of employment flows. Labor productivity growth in each economic sector has a low correlation with business cycle fluctuations in the unemployment rate and the flows into and out of unemployment. We also show that fluctuations in unemployment rates have a high correlation with changes in job-separation rates, supporting empirical evidence found in other countries that job destruction plays a crucial role in explaining cyclical unemployment fluctuations (Elsby et al., 2012).

After a contractionary monetary shock, the secondary sector reacts most strongly regarding increased job-separation and decreased job-finding rates. Also, in contrast to the primary and secondary sectors, real labor productivity falls in the tertiary sector after an interest rate shock. For the primary and tertiary sectors, the older workers (55 or older) experience an increase in the job-separation rate. In contrast, in the secondary sector, the impact of job destruction is felt across all ages and income levels.

Finally, we find that the idiosyncratic volatility of labor earnings increases in the secondary and services sectors after a contractionary monetary shock, confirming similar results for the U.S. (McKay and Papp, 2011; Storesletten et al., 2004). This increase in idiosyncratic earnings risk is also found in the lowest-income workers in the primary sector.

Our results show that job-separation risk and wage income volatility are countercyclical, confirming previous U.S. analysis (Storesletten et al., 2001) and reacting to monetary policy shocks. Chile's heterogeneous and countercyclical labor market risks are relevant because it indicates that the welfare costs of the business cycle can be higher than the estimates obtained from representative agent models (Storesletten et al., 2004).

Disclosure statement

The authors have no personal or material financial interests related to the research in this paper.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.latcb.2023.100092.

Appendix A

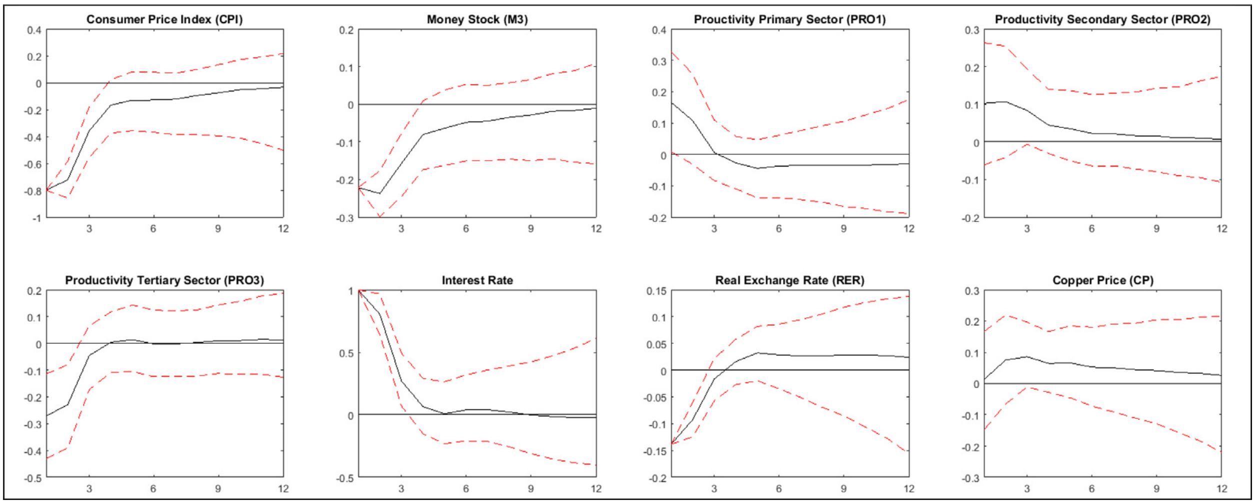

Fig. 5. Impulse-response function of the consumer price index, money stock M3, productivity in the primary, secondary, and tertiary sectors, real exchange rate, and copper price to one standard deviation positive shock to the interest rate.
Note 1: The black graph is the response, in standard deviation units, to one standard deviation positive shock to the interest rate.
Note 2: The dotted red graphs are the 90% confidence interval of the impulse-response function.
Note 3: By construction, the impulse-response function of the interest rate starts at one (one standard deviation)

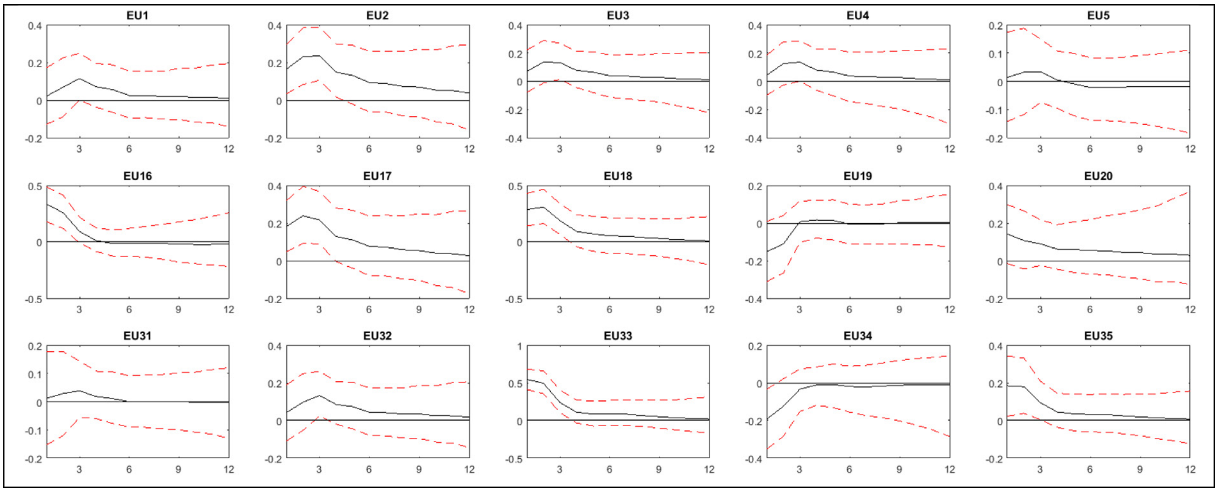

Fig. 6. Impulse response of the job-separation rate (EU*i*) to a positive shock to the interest rate (one standard deviation) in the primary sector.
Note 1: The black graph is the response, in standard deviation units, to one standard deviation positive shock to the interest rate.
Note 2: The dotted red graphs are the 90% confidence interval of the impulse-response function.

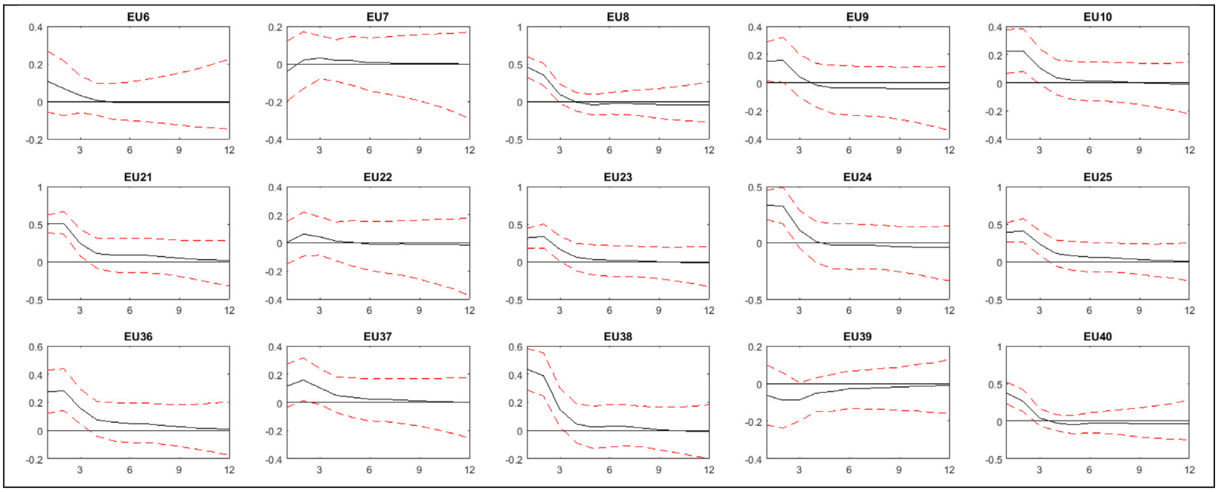

Fig. 7. Impulse response of the job-separation rate (EU*i*) to a positive shock to the interest rate (one standard deviation) in the secondary sector.
Note 1: The black graph is the response, in standard deviation units, to one standard deviation positive shock to the interest rate.
Note 2: The dotted red graphs are the 90% confidence interval of the impulse-response function.

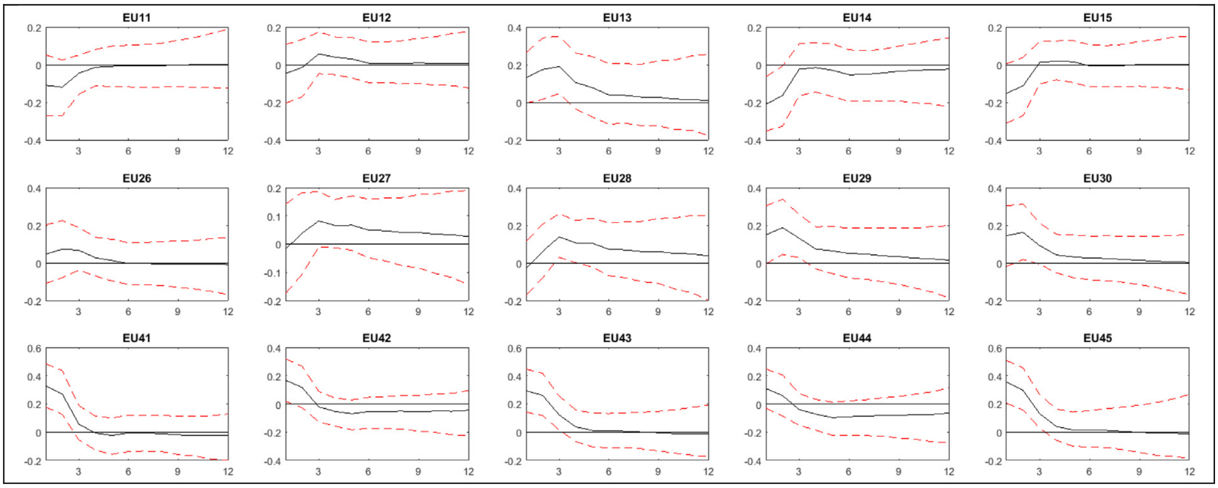

Fig. 8. Impulse response of the job-separation rate (EU*i*) to a positive shock to the interest rate (one standard deviation) in the tertiary sector
Note 1: The black graph is the response, in standard deviation units, to one standard deviation positive shock to the interest rate.
Note 2: The dotted red graphs are the 90% confidence interval of the impulse-response function.

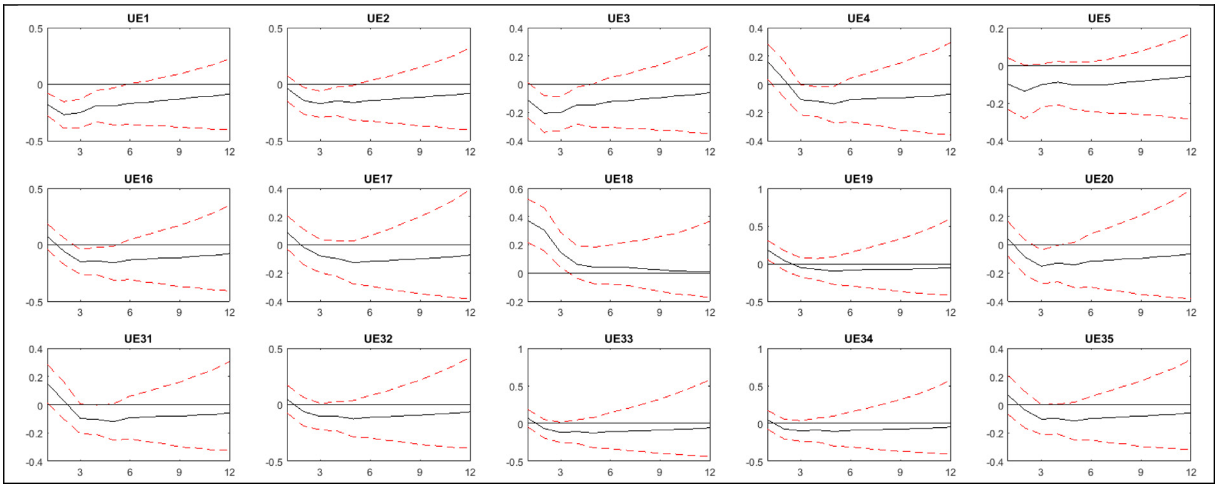

Fig. 9. Impulse-response of the job-finding rate (UE*i*) to a positive shock to the interest rate (one standard deviation) in the primary sector.
Note 1: The black graph is the response, in standard deviation units, to one standard deviation positive shock to the interest rate.
Note 2: The dotted red graphs are the 90% confidence interval of the impulse-response function.

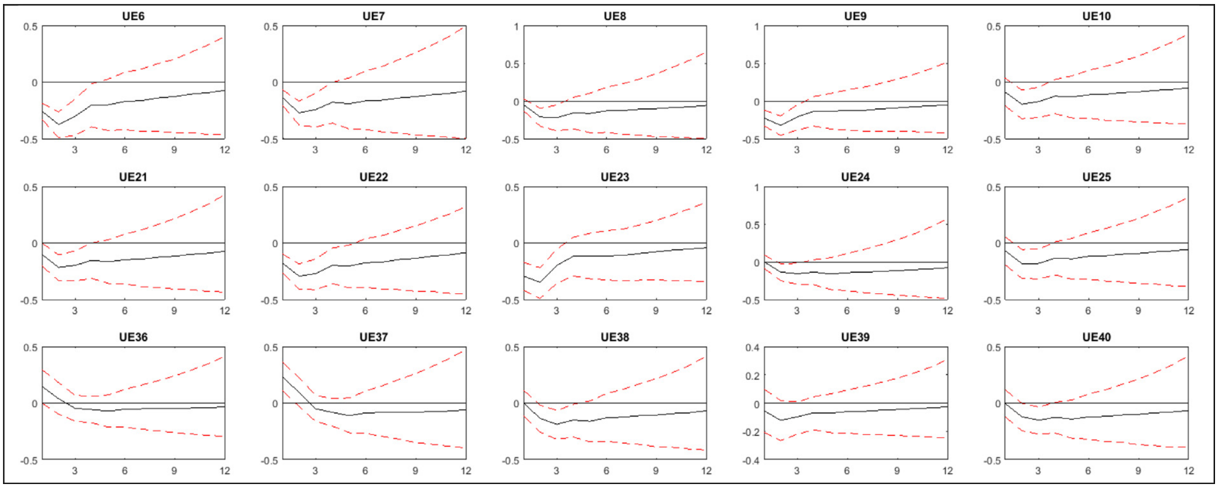

Fig. 10. Impulse-response of the job-finding rate (UE*i*) to a positive shock to the interest rate (one standard deviation) in the secondary sector.
Note 1: The black graph is the response, in standard deviation units, to one standard deviation positive shock to the interest rate.
Note 2: The dotted red graphs are the 90% confidence interval of the impulse-response function.

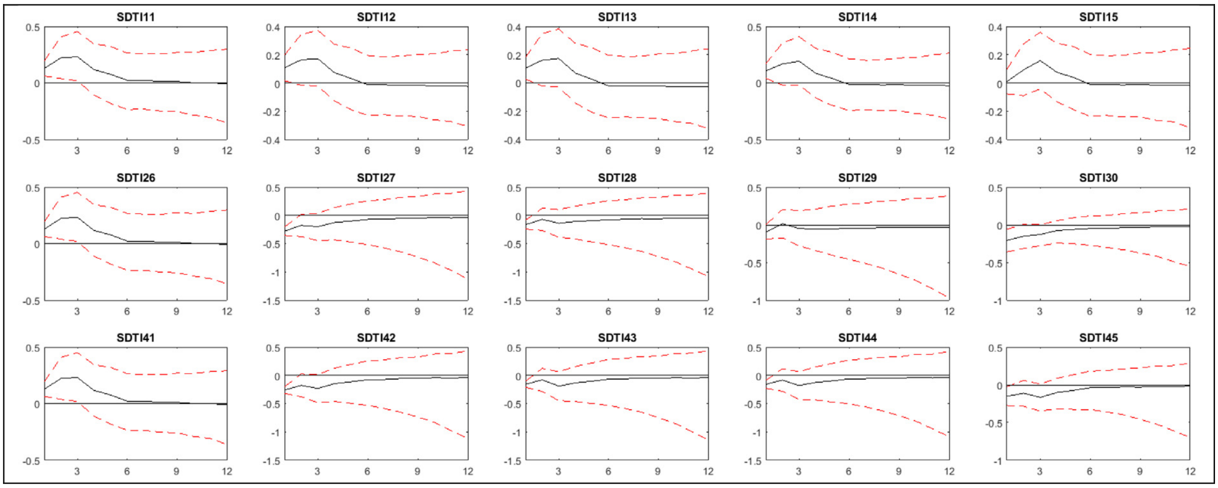

Fig. 11. Impulse-response of the job-finding rate (UE*i*) to a positive shock to the interest rate (one standard deviation) in the tertiary sector.
Note 1: The black graph is the response, in standard deviation units, to one standard deviation positive shock to the interest rate.
Note 2: The dotted red graphs are the 90% confidence interval of the impulse-response function.

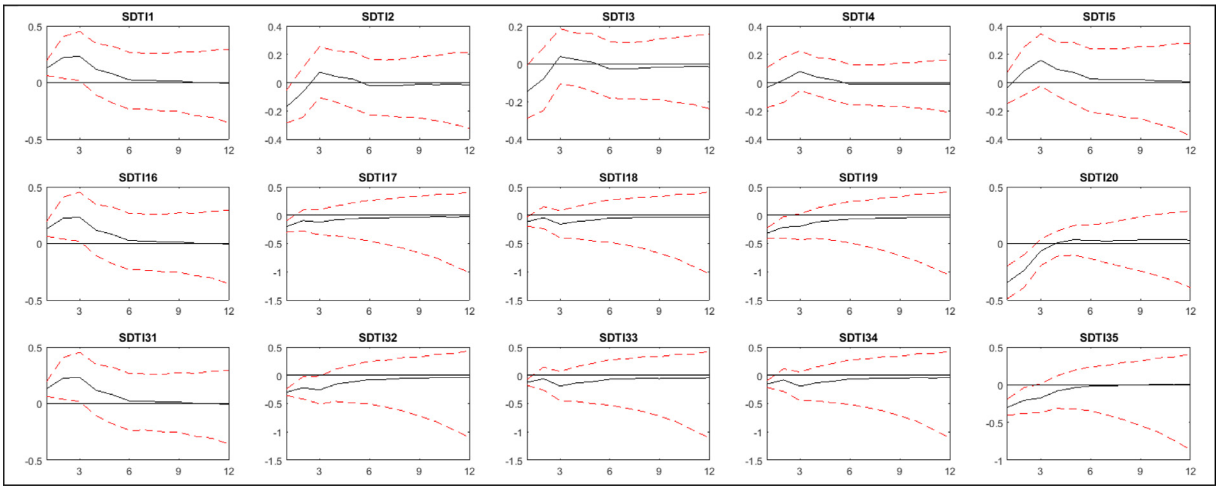

Fig. 12. Impulse-response of the wage volatility (SDTI*i*) to a positive shock to the interest rate (one standard deviation) in the primary sector.
Note 1: The black graph is the response, in standard deviation units, to one standard deviation positive shock to the interest rate.
Note 2: The dotted red graphs are the 90% confidence interval of the impulse-response function.

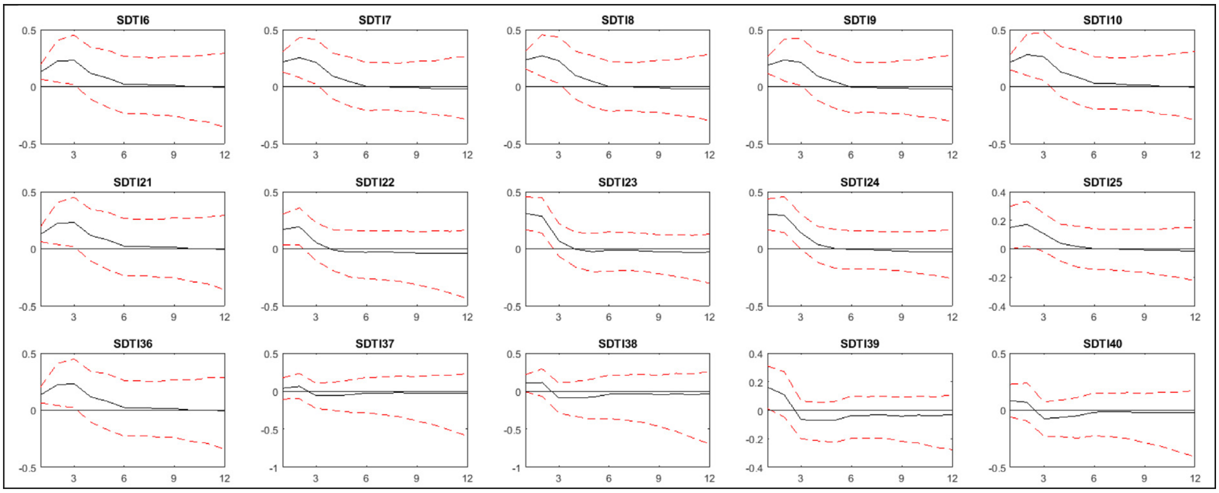

Fig. 13. Impulse-response of the wage volatility (SDTI*i*) to a positive shock to the interest rate (one standard deviation) in the secondary sector.
Note 1: The black graph is the response, in standard deviation units, to one standard deviation positive shock to the interest rate.
Note 2: The dotted red graphs are the 90% confidence interval of the impulse-response function.

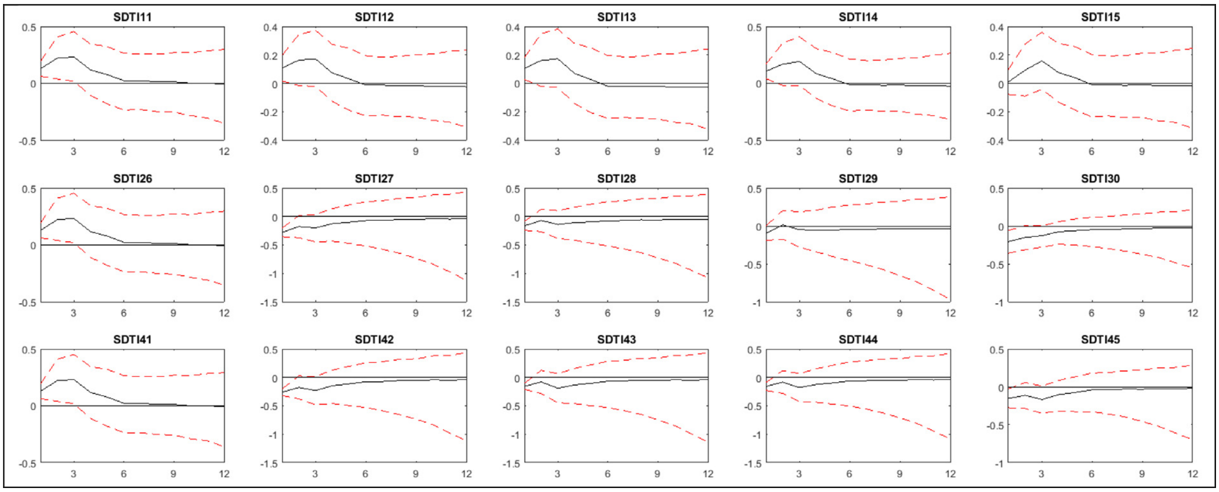

Fig. 14. Impulse-response of the wage volatility (SDTI*i*) to a positive shock to the interest rate (one standard deviation) in the tertiary sector.
Note 1: The black graph is the response, in standard deviation units, to one standard deviation positive shock to the interest rate.
Note 2: The dotted red graphs are the 90% confidence interval of the impulse-response function.

Appendix B

FAVAR estimation entails using a large sample size dataset. Therefore, using the monetary policy rate instead of the long-run interest rate would have significantly decreased the degree of freedom. The monetary policy rate was unavailable for the entire analyzed period, and its use would have reduced the sample size by two years.

Despite using a long-run interest rate instead of the monetary policy rate, one can undoubtedly refer to monetary policy and its effects since both rates are cointegrated. As shown in Fig. 15, both rates are positively co-moving over the quarterly period 1997Q4–2022Q2.

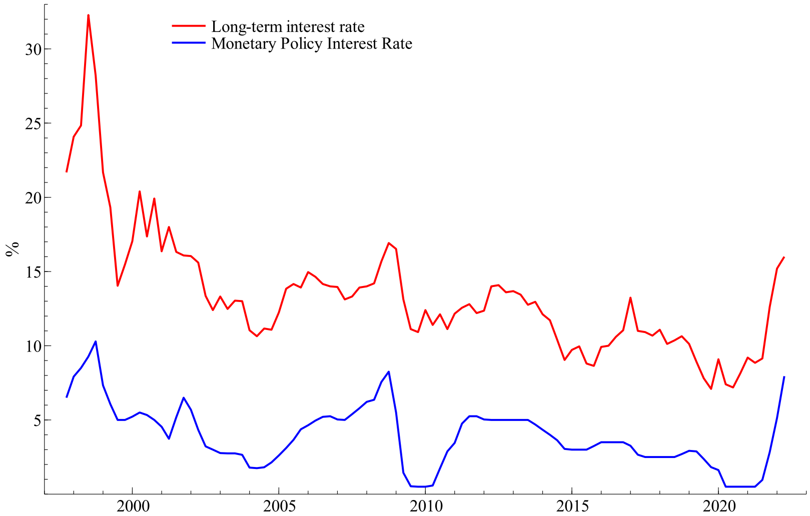

Fig. 15. Monetary policy interest rate and long-term interest rate: 1997Q4–2022Q2.
Source: Our elaboration is based on data from the Central Bank of Chile.

The Johansen cointegration test, reported in Table 11, indicates that both rates are cointegrated. Therefore, they have a stable and positive relationship in the long run. Furthermore, the estimated pass-through is close to one from the implied cointegration relationship.

Table 11
Johansen cointegration test.

$p-r$	r	Eigenvalue	Trace test	$Q_{0.95}$	p-value
2	0	0.15	22.99	20.16	0.01
1	1	0.06	6.38	9.14	0.17

Source: Own elaboration. $Q_{0.95}$ is the 5% critical value. $r$is the number of cointegrating relationships, and p is the number of variables.

Appendix C

Fig. 16 shows the response of aggregate job-separation (EU) and job-finding (EU) rates. While the EU exhibits a significant reaction lasting almost three-quarters, the UE response is insignificant. These aggregate responses emphasize the distributional effects of the monetary policy on workers and economic sectors. Then, by disaggregating the EU and the EU by groups (age, income quintile, and economic sector), as it was empirically done in the analysis, one can unhide the effects of monetary policy that otherwise would be limited to what is exposed in Fig. 16.

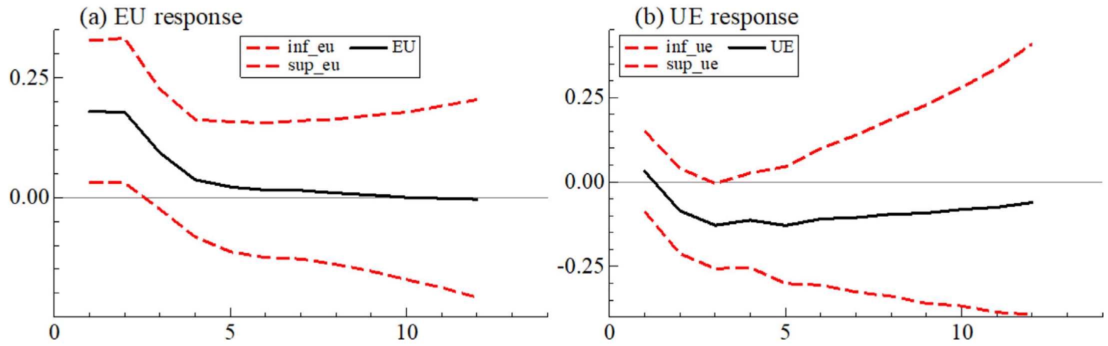

Fig. 16. The impulse-response function of the aggregate job-separation rate (EU) and aggregate job-finding rate (UE).
Note 1: The black graph is the response, in standard deviation units, to one standard deviation positive shock to the interest rate.
Note 2: The dotted red graphs are the 90% confidence interval of the impulse-response function.

Appendix D

Table 12 shows the exact composition of the 45 mutually exclusive groups according to an economic sector (primary, secondary, or tertiary), age (16-35, 36-54, ≥55), and income quintile (1, 2, 3, 4, or 5). For instance, group 10 represents people working in the primary sector, aged 36-54, with income on the fifth quintile.

Table 12
Group decomposition.

Group	EconomicSector	Age	Incomequintile	Group	EconomicSector	Age	Incomequintile
1	Primary	16-35	1	24	Secondary	36-54	4
2	Primary	16-35	2	25	Secondary	36-54	5
3	Primary	16-35	3	26	Secondary	≥55	1
4	Primary	16-35	4	27	Secondary	≥55	2
5	Primary	16-35	5	28	Secondary	≥55	3
6	Primary	36-54	1	29	Secondary	≥55	4
7	Primary	36-54	2	30	Secondary	≥55	5
8	Primary	36-54	3	31	Tertiary	16-35	1
9	Primary	36-54	4	32	Tertiary	16-35	2
10	Primary	36-54	5	33	Tertiary	16-35	3
11	Primary	≥55	1	34	Tertiary	16-35	4
12	Primary	≥55	2	35	Tertiary	16-35	5
13	Primary	≥55	3	36	Tertiary	35-54	1
14	Primary	≥55	4	37	Tertiary	35-54	2
15	Primary	≥55	5	38	Tertiary	35-54	3
16	Secondary	16-35	1	39	Tertiary	35-54	4
17	Secondary	16-35	2	40	Tertiary	35-54	5
18	Secondary	16-35	3	41	Tertiary	≥55	1
19	Secondary	16-35	4	42	Tertiary	≥55	2
20	Secondary	16-35	5	43	Tertiary	≥55	3
21	Secondary	36-54	1	44	Tertiary	≥55	4
22	Secondary	36-54	2	45	Tertiary	≥55	5
23	Secondary	36-54	3				

Appendix E

Table 13 shows, when possible, a statistical test for comparison of the average length of the response of the different groups in the primary, secondary, and tertiary sectors reported in Table 5.

Table 13
Comparison test of the average length response.

Hypothesis: $\mu_i - \mu_j = 0$	Job-separation rate (EU)	Job-finding rate (UE)	Wage volatility (SDTI)
	Increase		
Primary-Secondary	$t = 2.74^{*} p - value = 0.01$	-	$t = 0 p - value = 1.0$
Primary-Tertiary	$t = 2.41^{*} p - value = 0.04$	$t = 0.92 p - value = 0.38$	$t = 2.10 p - value = 0.06$
Secondary-Tertiary	$t = 1.30 p - value = 0.21$	-	$t = 3.54^{*} p - value < 0.001$
	Decrease		
Primary-Secondary	-		
Primary-Tertiary	-		$t = 0.33 p - value = 0.74$
Secondary-Tertiary	-	$t = 1.42 p - value = 0.19$	-

Note: * indicates statistically significant at a 5% level, μ_i is the average length response of sector i = primary, secondary, tertiary.

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